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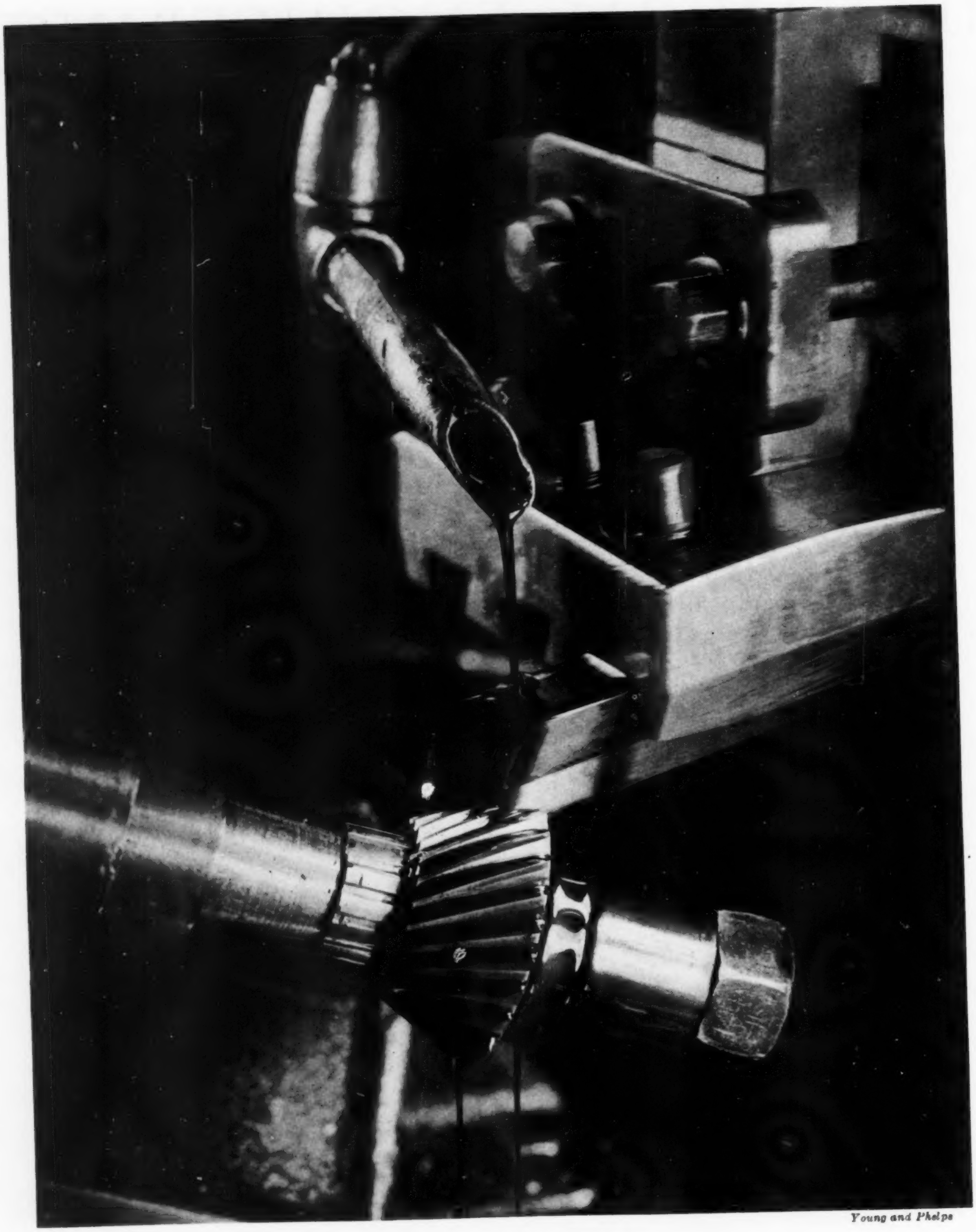


Young and Phelps

Generating a Spiral Bevel Gear

Volume 59
No. 6

MECHANICAL ENGINEERING

June
1937

GEORGE A. STETSON, *Editor*

The Resource in Youth

DURING recent weeks in ten student meetings held throughout the United States more than 1500 student members of The American Society of Mechanical Engineers, representing upward of 100 colleges, have come together for the purpose of presenting technical papers in competition for prizes, for the discussion of common problems for social intercourse with their own numbers and officers and members of the Society, and for visits to engineering plants and industries. Such impressive evidence of interest taken by young men still under the spell of their happy and self-centered collegiate existence in their relationship to the professional engineering society, which in later years must take over some of the educational and inspirational services of colleges and faculties, cannot be lightly brushed aside. The high hopes with which these young men are facing their future careers calls for serious consideration on the part of officers and members of the Society so that the immense vitality latent in this tremendous resource of the profession shall not be dissipated.

The leaven of optimism resulting from better times working in the country today holds much promise for the profession and the Society. Because of the able work of the Committee on Relations With Colleges, and of the honorary chairmen and student officers of the Student Branches, The American Society of Mechanical Engineers finds annually a great body of recruits to its ranks. Pursuing the wise course of making transfer from student to junior grade of membership easy, the Society is attempting to hold every year as many as possible of the approximately 1000 graduates. While the number permanently held is not yet as great as it should be, the will to increase it exists. But to the will must be added the means, and this is a problem to which members individually as well as collectively can afford to give the most attentive study.

Last month a plea was made for an increase in junior activities. No doubt an active junior group in the section to which a young graduate finds himself attached can do much to stimulate his interest and enthusiasm and lend him assistance and encouragement. But the means must go further than the work which younger men can do. The entire Society must be alert to the needs of these young men because with them lies its future. Professional and technical activities must be expanded and improved, for these provide the substance on which the young engineer must depend during his development. Opportunities for active service by younger men can well be increased, for it is a commonplace of cooperative effort that those who put the most into it get the most out of it.

To this task of individual development the publications of the Society are directed. Many an older man, respected by his fellows in the profession because of his attainments, will confess that he owes much to the Society's publications and to its varied activities. Younger men are looking expectantly to the great group of older men for inspiration, guidance, and opportunity, and where personal contacts cannot be made, the influence of publications may still be felt. It is on such grounds that the Committee on Publications and the editorial staff justify their policy of keeping the needs of the young man in mind in directing the Society's publications. This policy is most actively followed in Mechanical Engineering, and while results will be variously appraised, the ideal, that this journal shall keep alive the professional and educational ideal without which growth cannot proceed, is constantly in mind. As with the Society itself, so it is with Mechanical Engineering; one of its greatest successes will always be to retain the interest and support of younger men because it meets their needs.

Hood and Fernald

WITHIN the space of a few weeks The American Society of Mechanical Engineers lost by death two of its members, O. P. Hood and R. H. Fernald, who had served it long and faithfully and who left behind them records of achievement and examples of character that will live long in the memories of their friends.

The distinguished career of O. P. Hood, former teacher and chief of the technical branch of the United States Bureau of Mines, covered that period in the development of fuel technology which raised it to a place where engineers could rely upon the statistics covering the essential characteristics of this country's fuels and in which the art of combustion came to be generally understood. He represented the scientist-engineer in the public service at its high flowering and did much to justify a high opinion of the manner in which the government can serve its people. His kindliness and the rich resources of his personality are charmingly preserved in the simple statement of his optimistic philosophy set forth in his "Reflections," that appeared in the November, 1935, issue of Mechanical Engineering.

Dean Fernald, former chairman of the A.S.M.E. Power Test Codes Committee, was one of those vigorous teachers who impressed upon the generations of engineering students that came under his influence the high ideals of the profession. He possessed an uncanny understanding of the undergraduate mind and of the especial needs of young men. In the achievements of the men who sat under his instruction were harvested richer fruits than the life tree of a single individual can bear. It was a matter of justifiable pride with him that men trained under him held important posts, and that, during the recent depression they were so useful to society that they were continuously employed, almost to a man.

Both of these men will be sorely missed; but such was their mission and success in life that from their instruction and inspiration not merely two but dozens of men were trained to carry on their work.

An Interesting Suggestion

ON THE "Members' Page," to be found elsewhere in this issue, is printed a letter from Frank L. Eidmann in which it is suggested that The American Society of Mechanical Engineers undertake to set up an educational program for the benefit of its members, and that a committee on education be appointed to study the proposal. It is earnestly hoped that the views of other members on this suggestion will be frankly expressed so that it may receive the attention its importance merits.

Many a young graduate has asked himself the question, When my alma mater ceases to direct my education, to whom shall I turn? and has found a variety of answers. Some enter upon a course of self-directed study; others employ their after-hour leisure in graduate work in nearby universities. Correspondence courses attract a few. In rare cases junior-group activities of certain local sections of engineering societies provide an environment and a stimulus for the inquiring youth who strives to derive some tangible benefit through professional contacts with others with similar inclinations. Attendance at engineering-society meetings and the reading of technical books and magazines are the profitable recourse to which many turn. But in all of these, except graduate study, none presents a well-organized program in which the masters of the profession participate with the serious objective that the university provides. Professor Eidmann's plan, as a reading of his letter will disclose, contains this essential element.

To what extent the Society should enlarge the scope of its activities to take on the educational function proposed to it by Professor Eidmann is for its Council to decide. Much effort has been expended in recent years to increase the value of Society membership to young engineers, and it is the young engineer who will benefit if Professor Eidmann's proposal is put into effect. It is therefore important that the views of these young men be expressed. Within reasonable limits these views, and those of older men, communicated to the editor by letter, will be published in future issues.

Future of E.C.P.D.

TO LAST month's résumé of what the Engineers' Council for Professional Development has accomplished it is gratifying to be able to add a brief comment on its plans for the future, as divulged at a meeting of the Council on April 23.

President Compton's informal report, that 135 of the 149 engineering schools which grant engineering degrees had applied for accrediting, that 123 schools had been visited, and that 11 more will have been visited by June 1, was supplemented by a discussion of the future activities that may engage the attention of the Committee on Engineering Schools. Recommendations which were approved by the Council are as follows:

1 That the committee concern itself with the review and reinspection of institutions as need may arise.

2 That it cooperate in a proposed investigation of the evaluation of accrediting.

3 That it assist in the enhancement of the status of graduate study in engineering.

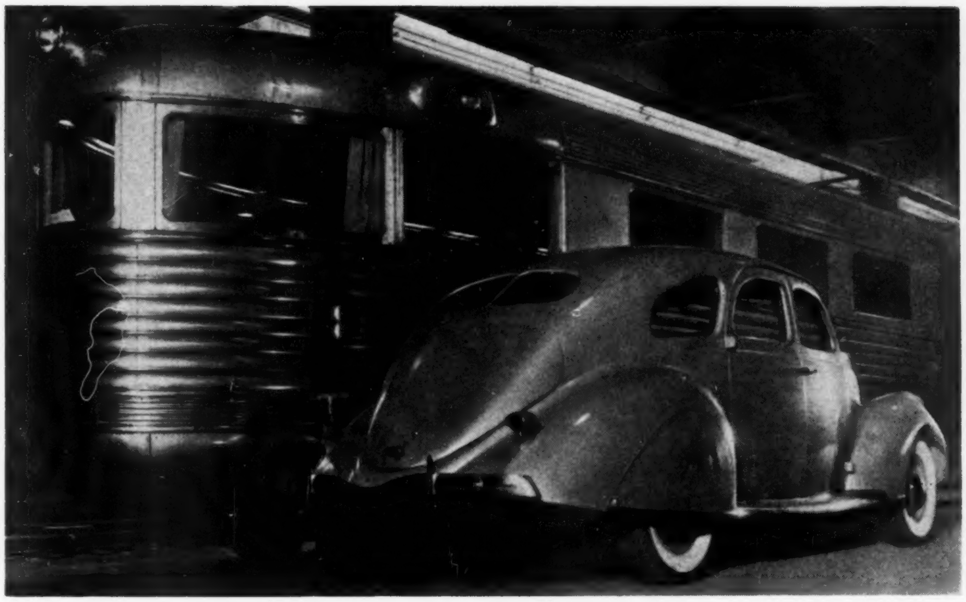
4 That it organize a consulting service for advising engineering educational institutions.

5 That it assist in improving standards at institutions which prepare students with advanced standing for transfer to engineering schools.

6 That it make a survey of engineering education utilizing the available information on the status of engineering education assembled in the process of accrediting.

It will be recognized that these proposals have sound merit; and while hazards may be involved in putting them into effect, they are not based on a desire to regiment engineering education or to restrict the individuality and initiative of the schools and their faculties. Indeed, one of the gratifying results of the investigations already carried out has been a quickened interest on the part of faculties and administrative officers in the work and methods of their schools. Unless the most stupid sort of leadership should prevail in the Council, of which, happily, there is now no evidence, such influence as the committee may have on engineering education will not hamper the most progressive schools and seems likely to raise the quality of the least progressive.

These plans which the E.C.P.D. has in mind are cited to prove the vitality of its leadership and as an indication of the kind of work it finds to do. Taken in conjunction with past achievements, summarized last month, they hold the promise that as long as this leadership is exercised by men of high caliber actuated by the best ideals for the profession, E.C.P.D. will continue to demonstrate by its actions what its name implies, professional development. But the matter cannot rest solely there, for, after all, E.C.P.D. is a council. Effective use of the deliberations of this council rests with engineers themselves, their professional societies, and the engineering schools with which they are so closely allied. Without this broader effort plans for the future will result in little real professional development.



TWIN ZEPHYRS

AUTOMOTIVE ENGINEERING *Applied to* RAILROADING

By E. G. BUDD

EDWARD G. BUDD MANUFACTURING CO., PHILADELPHIA, PA.

POINTING out differences between automobile and railroad requirements is easier than pointing out the similarities. Pneumatic tires unquestionably would serve a good purpose on railroads. Trucks and the car-body structure could be made much lighter. Wear and tear on the vehicle and on the passengers' nerves would be less. This has led to extensive use of rubber-tired rail cars in Europe. However, in this country, sound objections to the use of the rubber tires on rails exist, and, for this reason, the one conspicuous and outstanding feature of the automobile is, for the present, eliminated from the railroad vehicle.

Great skill and ingenuity were required to develop the steering apparatus for an automobile. None of this endeavor is required for the railroad car.

From the railroad's point of view in the earlier days, the only problem was carrying the maximum number of passengers from place to place with the least cost between terminals. They viewed the passenger car much as they did the freight car. Most of the people sat close together, and the less space devoted to nonrevenue load, the more the railroad was the gainer. The automobile, from the beginning, had to give the passenger a comfortable ride or the average man would not use it. The vehicle became a source of individual pride, and beauty of appearance was as much a requirement on the purchaser's part as appearance was when purchasing clothes. Before long, women were as sensitive about the appearance of their automobile as they were regarding their hats or their shoes.

To the railroad man, this did not seem so urgent a demand as it did to the automobile manufacturer. The Pullman Company, in its earlier cars, supplied beautiful woodwork, handsome draperies, and ornamental lighting fixtures and saw that the passengers had comfortable seats and bedding, as well as good food. Day coaches have been improved somewhat with the lapse of time, but the railroad has never felt that appealing to the riders' taste was essential. In our endeavors in the railroad field, we have felt that this appeal to the customer should be given the utmost attention, and, as a consequence, we have secured the services of the best artists and architects that we have been able to find. Appeal to the eye in a railroad coach, we have felt, was every bit as important as in the automobile.

$140 or $1400 per seat

Matters of cost are very important. The cheap automobile costs $140 per seat, while the standard railroad train runs to some $1400. On the other hand, the railroad can use its seating space for many more hours of the year and, thus, more than make up for the difference. Cost of fuel per passenger is greater in the automobile, but the railroad made great expenditures in building and maintaining roadbeds, terminals and

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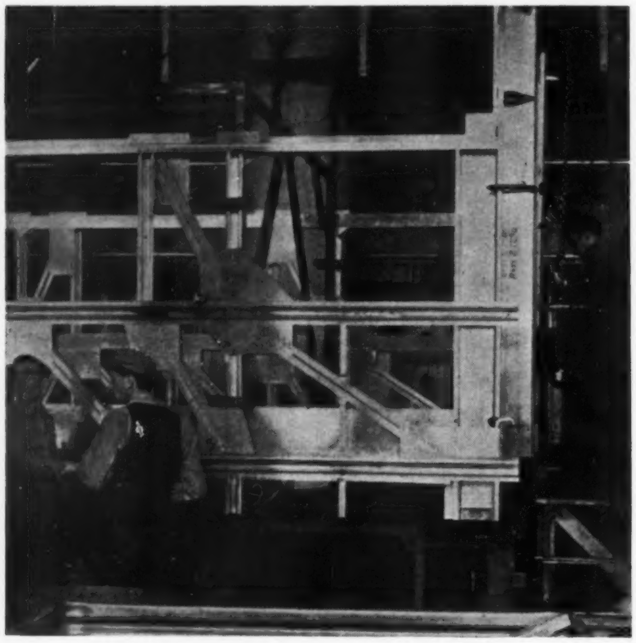


LIGHTWEIGHT RAILROAD-CAR CONSTRUCTION

rolling stock, with a large personnel in addition to the crews that operate the trains, and this huge expense has to be distributed equitably between freight and passenger business. Railroads, in the beginning, laid a roadbed which was suitable for the existing times and conditions and, year by year since, they have improved it, straightened curves, put on better ballast, and laid better rails, until they have a highway equipment that has cost vastly more than their capitalization. They are subject to stupendous taxes, which have to be paid by the consumer just as all other taxes are paid by the average citizen. All this has resulted in a large cost per mile of passenger transportation, which is partially direct cost—crew, fuel, and maintenance—and more largely a huge overhead cost, an economic condition which is far different from that of automobile and bus transportation, because highway building and maintenance, in the case of busses and personal cars, is done directly by the citizen and comes out of his pocket through another channel.

In the case of the automobile, increasing passenger miles results in only moderate savings to the owner, because at the end of 50,000 miles or thereabouts the automobile is worn out, and these 50,000 miles can be spread over several years or several months at approximately the same cost per mile. Railroads, however, can tremendously reduce cost per unit of transportation by increasing the mileage that equipment is run per day. Whetting the appetite of the average citizen for automobile riding does not materially reduce the cost per mile, but whetting his appetite for riding on the railroad does tremendously decrease the cost per passenger mile.

Several runs in this country have demonstrated that the average number of passengers carried one mile can be quadrupled by giving more attractive service and lesser fares and reducing running time between terminals. The effect of these better conditions is beyond our expectations and leads to the conclusion that the travel which can be induced by improved conditions is practically without limit.

When the Burlington Railroad announced a $6^{1}/_{2}$-hr schedule between Chicago and St. Paul, using lightweight, beautifully decorated trains, which ran smoothly and quietly, one competing road speeded up its standard old-type train to make the same quick time, and another built a compromise type of train, which was somewhat lighter than regular equipment and furnished and decorated so as to appeal to the rider's taste and comfort. This was all new service, and the trains were filled from the beginning. The Burlington's stainless-steel Diesel-driven trains then made two trips per day, each train running 883 miles, and its cars were still full, with a waiting list. Doubling the length of the train so as to carry twice the number of passengers still found all cars filled, and the road is again adding cars to the train. Overhead, terminal, and right-of-way maintenance charges have been cut to only a fraction of what they were per passenger mile under old conditions.

AUTOMOTIVE INFLUENCE UPON RAILROADING

Getting back more closely to our subject, automobile and airplane influence on railroad business has been felt on both the commercial and the engineering, or manufacturing, side. Light weight with strength was essential in the airplane, and the cost of the airplane and the cost of operating it, at least at first, was distinctly nonessential. In automobiles light weight was an essential, and if its use was to become wide spread, cost was an essential. First cost of equipment was the serious problem in the early stages of the railroad business, and, on regular trains, railroads quickly became conscious that a certain volume of travel would be theirs regardless of the fare charged.

Until now, railroads have felt that freight traffic was essentially theirs, and, as this income so greatly exceeded passenger revenue, most of the commercial attention of the railroads has been given to the freight end of the business. Consequently, in the period when the country was most prosperous, fewer and fewer persons used railroads for passenger transportation, and the railroads have become conscious of the fact that, regardless of charges, a considerable volume of passenger business would have to come to them for transportation, and they have been content with this business. This attitude of mind has discouraged passenger travel.

Certain railroads have seen this subject in a new light. Those leading into Chicago gave transportation at the rate of 1 cent per mile during the World's Fair, carried a great number of passengers, and found the transportation profitable, even though they were using heavy equipment. This demonstrated to the management of some roads the extent to which quantity transportation reduced costs, especially overhead and maintenance. This was followed by the introduction of equipment that weighed less than one half the old, had an attraction in style, comfort, and luxury, and cost more but was still able to more than double the daily mileage and cut the direct cost per mile in half. These attractions resulted in enormously increased traffic and demonstrated that some of the traffic, which had been lost to the automobile, could be regained. Simple figuring showed that if only 1 out of 25 passengers were taken off the highways, the number of passengers who ride on the railroads would be doubled. Durability of this new equipment was proved by some 3,000,000 miles of service, and the first Zephyr-type train was paid for at the end of 30 months from the revenue gained by its operation. Thus, the commercial problem seems to be solved, and the way is open for the introduction of a vast quantity of this modern and up-to-date rolling stock. The most careful and sound railroad leaders in the country appear to be convinced that passenger business, instead of being a debit to the railroads, can very promptly be changed into a source of large revenue, and the comfort and pleasure of the passengers be well served.

WEIGHT REDUCTION IN RAILROAD CARS

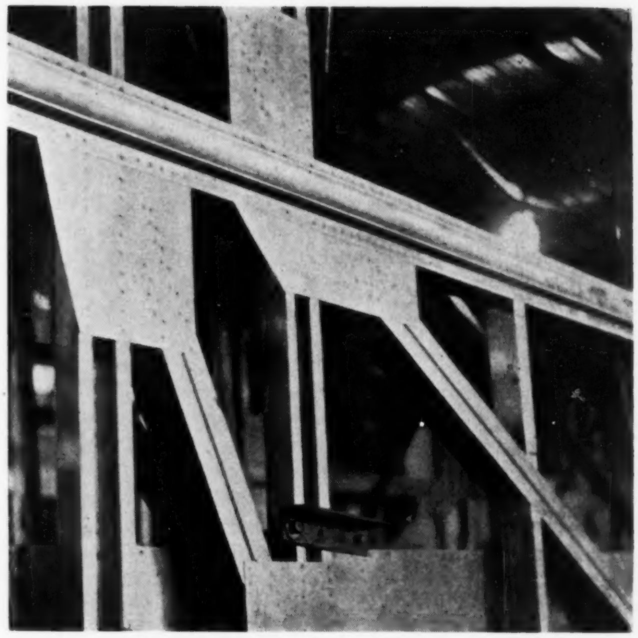
Desirability of light weight in automobiles and airplanes has resulted in general use of alloy steels, which, under heat-treatment, have strength and fatigue resistance which are many times those of the mild steels previously in general use. These alloy steels cost much more per pound, but their general use resulted in lowering the cost of the automobile. For a long time, the lowest priced car in the market used the largest percentage of the high-priced alloy steels. In a railroad car, the weight of steel required is proportional to the strength inherent in a single pound and its resistance to fatigue. Due to the size of the structure, using alloy steels that had been used in the automobile seemed impracticable. There, the steels are fabricated and finished to the required shapes and sizes and then subjected to a heat-treating process which gives them the desired ultimate strength and resistance to fatigue. To heat-treat railroad-car members before assembly is not practicable, and, due to its great size, heat-treating the whole body after it is erected also is not practicable.

The development department of the Budd Company, in its search for the proper and best material, found that the requirements were best met by an alloy steel containing 18 per cent of chromium and 8 per cent of nickel and that, by cold rolling this material to an elastic strength of 120,000 lb, it could then be fabricated to the desired shapes and dimensions without bringing its ductility below the desired point. Since this material is proof against atmospheric deterioration, thin sections can be used with the assurance that they will retain throughout the life of the car the strength which they have when the car is new. Use of this material is a fair example of how the objectives that the automobile engineer attained in his product must be achieved differently in railroad cars.

DESIGN MUST PERMIT READY ASSEMBLY AND INTERCHANGEABILITY

The constant object of the automobile designer has been to make the parts composing the complete vehicle of such a design that they permit ready assembly and with a degree of accuracy that assures interchangeability. In our plan for manufacturing railroad cars, we had to face this same problem but could not solve it by precisely the same methods as are desirable in the automobile. Elaborate dies and tools are made for an automobile model because a large number of identical vehicles is to be produced from these tools and any expenditure that is made for equipment can be divided by the total production. Similar assurance of a large volume of complete cars of identical design is lacking in the railroad business. To attain these manufacturing economies, the car had to be constructed of certain definite units that could be spaced and placed in the structure to permit varying lengths, varying window spacing, and varying subdivisions to suit the interior furniture. This allows manufacture of the units in quantities and by special tools, with the assurance that the same unit can go into a sleeping car, a day coach, or a dining car, and that doors and windows can be spaced to suit the essential requirements. The objective of our car designers is the same as that of the automobile designer but the methods have to be distinctly different.

Many years ago, the author tooled up and produced the parts for what was called the Brinkerhoff car, used in the first subway built in New York City. At the time, we built elaborate dies, expecting that many of these cars would be used. We produced 200 of them, found that no one wanted any more, and scrapped the dies. Later, Edwin H. Harriman fathered the McKean motor car, which was a most progressive move. We built the outer sheathing of this car by dies, forming windows and frame shapes. Here again, after building about 100 cars, the project was stopped, and the dies were of no further use. These two experiences did not yield us any money, but they gave us sufficient warning, and, when we again undertook car building, we recognized that the design should avoid using elaborate dies.



DETAIL OF WELDED CAR CONSTRUCTION

PARTS JOINED BY NEW ELECTRIC-WELDING METHOD

Automobile engineers have perfected the heat-treating process to a marvelous degree to get the best results from the carefully made alloy steels. We join our parts by electric welding, and, here at the start, we found the mischievous results of heating certain high-alloy steels. Only after a long, patient, and expensive experience, did we find a means of applying the current for the weld to give a proper heat-treatment to the part welded. We almost had to make our minds work backward from the way that they normally worked in the automobile business, and, yet even in this problem, the experience gained from the automobile heat-treating processes was of value in developing this method which differs so much from normal heat-treating. The automobile man heats his material by flame or electricity and cools it by water or oil. In our local welding, we heat a definite mass to a definite temperature in a short time by electricity and then cool the molten metal by the cold steel that surrounds it, leaving the metal in the weld thoroughly annealed. The precision of welding methods has given a new meaning in strength and reliability to structural attachments.

Painting methods used within the car are very similar to those developed by the automobile plants. Outside, the car needs no paint, and great economy in the original cost and in annual maintenance is attained by omitting the paint process.

ELIMINATING CAR AND OUTSIDE NOISES

The great bugaboo in automobiles has always been noise. Cars were noisy in the early days until the marvelous gear development that has taken place in the last few years has given us, as far as gears are concerned, an almost silent vehicle. Engines and valve tappets and springs were noisy. These have been quieted to a great extent, but, as we eliminate one noise, we discover another, which, while perhaps not so loud, is equally as annoying. In this way, the automobile builder has traced rattles and rumbles and squeaks, eliminating first one

and then another, until he has achieved a comparatively quiet vehicle. Railroads have paid little attention to noise in their cars. Couplers bang and groan and scrape in a most outrageous way. Wheel flanges scrape and squeak. Rail joints make a continuous click. Springs groan and squeak. Rubbing plates on the trucks complain to the patient passenger.

In the early stages, we made a great point of producing a quiet car. Articulated cars, with trucks between the units, are incomparably quieter than any of the old type. Nobody sits directly over a truck, and, consequently, he hears less of the groans that the truck itself produces and less rail-joint noise. Coupler noise, together with rubbing together of car ends and jarring and bumping between cars when either acceleration or retardation occurs, is eliminated altogether. A double bottom in the cars and sound insulation have reduced outside noises.

Then, noises within the car became more pronounced. Flat surfaces, which were in continual vibration from motion of the cars, made sounding boards that produced and magnified these noises. In the case of rooms, the passenger sitting within a room has his voice echoed back to him when he talks. This seemed a troublesome problem, and, only recently, has a type of partition been produced which practically eliminates this noise. Probably we will find other noises, but we certainly have gone a long way toward providing the rider in the railroad vehicle with a little of the peace and quiet of home. The rubber mattress is quieter than the spring. Perhaps, we may look forward to the time when our most serious noise will be the rattle of the soup spoon in the plate. This noise problem has been almost identical with that which has been so successfully met by the automobile builder.

QUICKER ACCELERATION AND BRAKING REDUCE RUNNING TIME

Another very interesting comparison can be made between the two types of vehicle. Those of us who have used automobiles for years are surprised to find how much we continue to reduce the time between starting and finishing a familiar ride. Between my home and my business, the elapsed time continuously seems to be less, and yet travel is safer and not more rapid. Improved acceleration and better brakes enable a reasonable average speed to be maintained, and, when slowing down or acceleration is necessary, it is accomplished in fewer feet. We climb hills at the same speed as we descend, and, yet, only a few years ago, everybody had to race to overcome a certain steepness of grade, and, if a driver put his car in low gear and crawled up a hill, he tried to make up time on the other side by racing down. This did not make for earlier arrival but did add to the hazards of driving.

Much the same conditions as now exist on the railroads existed fifteen years ago in the automobile business. The weight of what has been called the standard-type railroad train has been so great in proportion to the power of the locomotive that whenever a slight upgrade was met speed would drop; whenever slakening speed was necessary, slowing up covered a long distance; when the locomotive engineer needed to accelerate, several miles were required to regain speed; when he made a stop, he began to slow up five miles before his stopping place, and, when he got under way afterward, another five miles was needed to attain running speed. On down grade, they would run at maximum speed, although we are all well aware that a moving vehicle is not so well under control on a down grade as it is on the level or the upgrade. This was a hazard.

In designing trains, we have cut weight to one half or less, maintain an equal collision strength with the old heavy cars, because we use material that is four times as strong, and keep the horsepower of the pulling unit high enough so that the weight of the train per horsepower is 400 lb or less. Also, the best obtainable braking mechanism has been put under the cars. By this means, we can start or stop quickly, climb hills at the speed that we descend, make the total elapsed time between destinations marvelously less than has ever been attained before, and, at the same time, eliminate risks that existed with the old type of equipment.

After all, the railroad car and the automobile are road vehicles. They are both governed by the same laws of motion. What is good and true for one is also good for the other. Conditions of operation have, perhaps, been more difficult for the automobile than they have been for the railroad vehicle. The best highway in the world hardly equals the smoothness of a very poor rail. Few automobiles are ever handled by such skilled men as are found at the locomotive throttle or in the roundhouse. Once an automobile leaves the factory its use or abuse is not subject to regulation and yet a faithful performance is expected.

Perhaps automotive development has gone beyond that of the rail vehicle on account of these very difficulties. Now, however, the railroads have also been experiencing trouble. True, the trouble has been financial rather than one of operation, but, again, this comes back largely to the type of equipment. If automobile equipment had not always been in advance of public demands, the manufacturers would have experienced even worse financial difficulties than have the railroads. They might have failed. The railroads, however, dare not fail. The whole country would go down with them. They must overcome their difficulties, and, realizing this, railroad management will be wise to take a few leaves from the book of automotive experience.

THE "DENVER ZEPHYR"

Machine-Tool Builders' Contributions to MASS PRODUCTION *of* AUTOMOBILES

By F. W. CEDERLEAF

EX-CELL-O AIRCRAFT & TOOL CORP., DETROIT, MICH.

EACH STEP in advancement of automotive design has been directly or indirectly felt by many affiliated industries which necessitated their making changes or similar improvements to keep abreast of the new development. This is especially true of machine-tool builders who can vouch for the fact that the ever-changing demands of the automobile builder are the primary incentive for changes and improvements made in machinery design and manufacture during the last few years. The benefits of these improvements have been felt through all industries where machine tools are used.

One of the automotive engineer's major functions is to make the public unconsciously dissatisfied with today's cars by offering better vehicles at lower prices each year. This automatically dictates to the machine-tool builder that next year's production equipment must supply higher quality parts with lower labor costs. The demand for closer tolerances, trouble-free automatic operations, less down time, and more pieces per hour is never ending and is coupled with another that the machine be more or less standard or flexible so that it can be retooled for the next year's parts with the minimum change. These demands have been responsible for keeping the machine-tool engineers on their toes so that they can keep in step with the progress of the industry.

No machine-tool manufacturer can meet these demands alone, any more than one automobile company can succeed due to its own individual efforts. F. C. Pyper sounded the keynote to engineering progress in his paper "Developments in Close Machining Practice in Automotive Production" which was delivered before the Society of Automotive Engineers last January. He says:

> In the early days of the automobile each manufacturer developed his own processes of fabrication and carefully guarded them from his competitors. It was reasoned that any policy approaching an exchange of ideas and experiences would result in a certain uniformity of operation which would, in a measure, destroy normal competition.
>
> Before we, as engineers, can properly gage our progress, we must recognize the fact that the present policy of the manufacturer to share his experience with competition has been a most important factor in the development of machinery and equipment.
>
> Contrary to the early belief this policy has not resulted in a duplication of practice and instead we see today as great a difference in our process of manufacture as ever in the history of the automobile.
>
> The reason for these differences is not necessarily due to a difference of opinion as to the efficiency of equipment. Nor is it because of an important diversion of thought as to methods of manufacture. Selection of equipment must always be based upon such governing factors as volume requirements, necessary accuracy, financial investment involved, existing equipment; in short, its adaptability to the requirements.

Today, no doubt as to the value of the exchange of ideas among so-called competitors exists. A simple example of this is the case where a manufacturer of automotive poppet valves was requested by his customer to copperplate the stems after finish-grinding. No trouble was encountered with the inlet valve, but all attempts to plate the Silchrome exhaust valve were unsuccessful. Outside plating experts were called in, but they were equally unsuccessful. Feeling satisfied that it could not be done, the manufacturer loaded his portfolio with the failures and presented them to the customer, only to be shown some beautiful samples of "just what we want" which had been submitted by a competitor. A visit to the competitor's plant was quickly arranged, and a careful comparison of the methods used disclosed that the only apparent difference between the two plating installations was that the competitor's was new, while the other was several years old. Finding nothing else wrong, a new plating tank was built, and all new equipment was provided, with the result that the part was plated without difficulty. About a year later, the competitor was in a similar situation and could not determine the cause. He called upon this manufacturer and requested information concerning exactly what the other had done to overcome his earlier trouble. The competitor was not long in realizing that he needed clean equipment.

MACHINE-TOOL IMPROVEMENTS GRADUAL NOT REVOLUTIONARY

Contrary to the impression that some advertisements attempt to convey to their readers, the improvements offered each year by machine-tool builders are not revolutionary but on the contrary are gradual and well in keeping with the refinements developed annually by the automotive industry. The danger of a machine-tool builder developing a new product that would render obsolete all other similar-purpose machines now in use, is no greater than that of an automobile company designing a new model that would force every owner, by economic necessity, to scrap his present car and purchase the new vehicle.

Many theories, giving reasons why the world's progress must be slow, have been advanced. These are beyond the scope of this paper, but this slow progress is not due to any shortage of revolutionary suggestions and ideas. C. F. Kettering is reported to have once said "It isn't what you know that counts, but it's what you get done." Likewise, he has been credited with stating that all the instruments and machines in his research laboratories in Detroit were used for the single purpose of "penetrating the human skull."

The duty of the master mechanic in a manufacturing plant is to supply the production department with tools that, when

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operated by unskilled men with minimum supervision, will make parts to engineering tolerances. Obviously, his job is never completed. First, his department must prove that it can be done by doing it, which he finds is really easier than keeping it done. Each foot of progress must have wedges applied to the rear wheels to keep it from backing up on him.

The late Albert Champion had an ingenious way of applying a "no back." After a difficult job had been licked and was running smoothly, he would send an analytical chap, not necessarily an engineer, to record in detail every move and motion of the operation. This lengthy report was filed in a safe without any discussion. Three months, six months, or a year later, when the superintendent of this particular department complained that he could not make the product to meet the tolerances shown on the blue print or at the rate specified by the time-study department, Mr. Champion would withdraw this original manuscript from his safe and inform the sobbing executive that, if he would operate the machines the way he had formerly done, he would encounter no difficulty.

As previously mentioned, progress is slow. For instance, 10 years was consumed in reducing the tolerance on the diameter of a cylinder bore from 0.001 to 0.0005 in. In 1926, the majority of the automobile companies specified a tolerance limit of 0.001 in. for out-of-round and taper in cylinder bores. Today, only two or three are able to produce these bores to within 0.0005 in. out of round and taper. This does not mean that the industry has been standing still for these 10 years. Progress toward the goal demanded by the automotive engineer, namely, better quality at lower cost has been steady. Hardly a branch of industry has not felt this demand, and any prolonged failure to heed it soon found that company out of the race.

METHODS OF MACHINING CYLINDER BORES SINCE 1926

In 1926, several different methods were used to machine bores of automobile-engine cylinders. Some companies used a piloted reamer for the first operation. Others used the so-called "stubbing" operation, a reamer without a pilot. The second operation universally employed a piloted, top and bottom, single- or double-lip, boring bar which would produce correctly located bores. The next operation used a floating reamer to follow the previously bored holes and ream them to size, after which they were either honed or burnished. Although these methods were generally accepted as being satisfactory, at times in these 10 years, the automotive engineer demanded a better product. Whenever complaints of excess oil consumption, piston slap, and noisy engines came from the field, the engineer would shrug his shoulders and merely state that these troubles were not found in the experimental engines, and, therefore, if the shop would build the parts to conform with the blueprint, the troubles would not be experienced.

As better measuring instruments became available, he was able to prove his contentions, with the result that the spotlight remained focused on the manufacturing division. Unable to obtain greater-precision machine tools at that time, selective assembly was the only recourse. Eight or ten different sizes of pistons were graded and stocked. Cylinder bores were measured and marked to correspond with the pistons. As a double check on the engine-assembly line, a feeler attached to a fish scale was assembled with the piston in the cylinder bore, and a scale reading taken when the feeler was removed. This determined whether or not proper selection had been made.

At times, field trouble was traced to cylinder bores being out-of-square with the crankshaft center line. Attempts were made to correct this trouble by using a piloted boring bar with single-point tool as a substitute for the final floating-reamer operation. Two objections to this method were (*a*) it necessitated a feed of about $^1/_{32}$ in. per revolution instead of $^3/_{16}$ in. which was readily obtained with the multiple-blade reamer and (*b*) holding size with the single-point high-speed tool was difficult. Consequently, most manufacturers returned to the floating reamer and, thus, left the piston-ring boys holding the bag for a while.

Then, came the cemented-carbide-tipped tools. Even this new cutting-tool alloy could not revolutionize the industry overnight, as none of the then existing machine tools could operate at the proper surface speed for this new material to attain its greatest efficiency. But the automotive engineer dictated, and the machine-tool industry responded, with the result that today carbide-tipped tools, which run at a surface speed of 400 fpm in spindles with bearings made for this service, are producing cylinder bores with an alignment that was formerly only obtained with piloted boring bars and, in addition, are holding a less than 0.0005-in. tolerance much more readily than the 0.001-in. limit formerly attempted with floating reamers. Instead of having 8 or 10 different sizes of pistons, plus the fish-scale assembly, getting along with from one to four sizes of piston and nearly interchangeable manufacturing is now possible.

MANY INDUSTRIES CONTRIBUTED TO TOLERANCE REDUCTION

To record all engineering, experimenting, and capital invested to reduce the tolerance would require volumes and would cover all industries including machine-tool builders, cutting-tool manufacturers, steel companies, measuring-instrument makers, gage manufacturers, abrasive industries, and bearing manufacturers to mention only a few. In these 10 years, the equipment developed expressly to improve the tolerances of automotive-engine cylinder bores, included reaming and honing machines, hones and hone holders, measuring instruments, reamers, floating-reamer holders, cutting materials, cutter-grinding machines, and many other products that were offered as a means to attain this objective.

Consider for a moment the cycle of progress as it pertains to finishing a round cylinder bore in an automotive engine and note the part that the machine tool plays in this picture. As the date of introduction of high-speed steel is more or less the same as that when automobile production passed from the experimental to the production stage, a start can be made from this point, and the carbon-steel era ignored. The first picture, back about 1906, is single-spindle boring machines operated by skilled operators, using single-point high-speed tools in piloted boring bars, traveling at approximately 80 rpm or a surface speed of 80 to 100 fpm, at a feed of about 0.015 in. per revolution, or a cutting time of 4 min for 6 in. Even in those days, the allowable tolerance probably did not exceed 0.0015 in. out of round or taper of bore. Next to enter the picture, as mentioned before, was the high-speed multiple-blade reamer which did not change the revolutions per minute of the spindles but did increase the feed to about $^3/_{16}$ in. per revolution, thus reducing the cutting time to $^1/_3$ min. By using various ingenious floating holders and special reamer-grinding machines, the tolerance was reduced from 0.0015 to 0.001 in. and the skilled operator replaced with an unskilled man.

CEMENTED-CARBIDE TOOLS REDUCE TOLERANCE

As previously mentioned, this method with various minor changes continued from about 1926 to 1935, when the first production machines were built for specifically utilizing the advantages of the new cemented-carbide tools. Mainly due to the high cost of this new material, a single-point tool was again used, but the surface speed was increased to about 400 fpm with a resulting spindle-speed increase to around 400 rpm, and the

feed was reduced to approximately 0.007 in. per revolution which increased the cutting time to slightly over 2 min.

However, this operation, as it stands today, can be handled by an ordinary operator who, day after day, can produce bores which have a finish never dreamed of by skilled toolmakers of 25 years ago and a roundness variation of consistently less than 0.0005 in., easier than he could have bored them to a 0.002-in. tolerance with toolroom equipment available during the high-speed-steel era of 1912. If the past cycle of cylinder boring is any criterion of future development, the next logical step will be a tungsten-carbide multiple-blade reamer operating at 400 fpm surface speed and a $^3/_{16}$-in. feed per revolution. To accomplish this would require considerable development of reamer-grinding and lapping machines, and likewise, possible changes on reaming spindles.

SIZE AND ALIGNMENT OF PISTON-PIN HOLES A HARD TASK

Piston-pin bores in pistons have been another elusive task to keep the master mechanic awake at night. Just when he thought the problem was solved, material would be changed, or tolerances reduced, or pistons made lighter, any one of which would upset the whole production line-up. The two principal problems were size and alignment of holes. Before the present use of precision boring machines which is almost universal, for this operation, most plants attempted to maintain alignment by piloted boring bars with high-speed steel tools and then obtain size with solid reamers piloting in previously bored holes, the pistons being held by hand in some cases to prevent distortion. As the cost of these solid reamers was excessive, many attempts were made to use adjustable types but without much success. One plant increased the life of a solid reamer from 1000 to 10,000 holes by reverting to carbon steel instead of using high-speed steel. This was based on the principle that, as the reamer was used for sizing and did not operate at surface speeds which were detrimental to the temper of the tool, advantage was taken of the denser alloy carbon steel as compared with the saw-tooth edge structure of high-speed steel.

Demands for more positive means of obtaining closer tolerances on piston-pin bores were first felt by the machine-tool industry about 1928. The automotive engineer again created the demand by deciding to increase the engine compression with resultant piston-pin knocks. Fitting the pin tighter in the piston eliminated the knocks but caused piston scoring because when the pin length increased after the engine was heated, the skirt was pressed against the cylinder wall with sufficient force to cause scoring. This was before the days of tin plating.

Two-diameter piston pins and holes were tried, but they were costly. One method, used successfully for a long time, was a piston pin with a saw slot added to the free end, reducing the press-fit friction in the hole and yet having sufficient tension to prevent pin knock. To obtain an economical pin-hole-reamer life, a tolerance of 0.001 in. was allowed on the hole in the piston, which necessitated selective grading and fitting of pins in assembly. This also meant that the bronze bushing in the connecting-rod small end must be machined to different sizes to suit the pin size as too much clearance at this point also produced a pin knock.

PRECISION BORING MACHINE BECOMES A PRODUCTION TOOL

At this time, the precision boring machine stepped out of the laboratory class and went into production. The results were so superior to reaming that the engineering department immediately reduced the limits in the small end of the rod from 0.001 to 0.0004 in. Specifying this limit and obtaining it were two different things. Plug gages, varying in size by 0.0001 in., were used for accepting or rejecting the work, and many battles between production and inspection, as to the exact size of the hole, occurred. The gage maker stepped into the breach with an indicating instrument that read the same for all concerned, which, although settling the argument as to correct size, also disclosed an out-of-round condition that was not shown with the plug type. To correct this condition, considerable testing was required to find ways and means of clamping the part without distortion.

Today, practically all piston-pin holes in pistons and connecting rods are bored in precision machines using diamonds for nonferrous metals and the tungsten- and tantalum-carbide tools for iron and alloy-steel parts. Standard tolerances vary from 0.0002 to 0.0003 in., and operators in regular production have made as many as 180 parts per hour to this limit, with less difficulty than a skilled toolmaker can ream a hole to double this tolerance, and with an alignment that was never before attained by any method.

A few makers of high-priced cars avoided piston-pin trouble by using oil holes drilled in the connecting rod, thus allowing oil to be forced from the crankshaft bearing through the rod to the piston pin. This method was successful but was generally considered too expensive for cars in the lower-price brackets. However, one company, in desperation, finally decided to tool for it and hoped that its master mechanic, with the help of machine-tool and cutting-tool engineers, would find a way to reduce the cost of drilling this long hole, which at that time was about 7 cents per rod, to an economical figure. The first machines used were so-called "rifle drillers" using a high-speed steel-tipped oil drill with a hollow shank, which was gripped in a friction-type chuck and set so that when the drill failed to cut at the standard feed, the chuck would turn and stop the machine. Cutting oil was fed through the center of the drill at a high pressure, thus forcing the chips out through the drill flutes. As was expected, tool cost was high and production per machine very discouraging. At the end of the first year, after these machines had been installed, the tool cost for the oil-hole-drilling operation was 3 cents per rod.

During the next three or four years, several other machine-tool builders had, at the request of master mechanics, started work on this problem. Today, the same operation is performed but in a different manner. Standard, extra-length twist drills have replaced the tubular oil rifle drill. Hydraulically controlled feed has replaced the friction chuck, and the drill enters the connecting rod to a predetermined depth, is automatically withdrawn, and then returned by rapid traverse to within 0.005 or 0.010 in. of its previous stopping point. The labor cost of drilling has now been reduced considerably, and the drill cost per rod is approximately 0.3 cent.

MACHINING CONNECTING RODS AND BEARINGS

Before leaving the subject of connecting rods and bearings, it might be interesting to review some of the tooling developments which were, in part, responsible for the now "taken for granted" fact that an automobile can be driven an entire season without worry about the next bearing "take-up" time.

Ten years ago, babbitted-bearing connecting rods were in more or less universal use. Finishing the large hole, after babbitting, was accomplished with a reamer, varying in design from the multiple-blade expansion type to a single blade, the part generally being fed to the tool by hand. As indicating-type measuring instruments were not then available, roundness and accuracy of these bores were not very good. When assembled in engines and run for a few thousand miles, the high spots on the babbitt were quickly worn off, causing excessive clearance and bearing knocks. To correct this trouble, the car

was taken to the garage, connecting-rod caps removed, several shims taken out, and caps reassembled. The garage mechanic, to give a quiet running engine, would set these bearings for a metal-to-metal fit, tow the car around the block three or four times, and then deliver the car with the engine running and the warning that the car must not again be driven at a speed exceeding 25 mph for the next 500 miles under penalty of burned-out bearings. After the 500 miles, the high spots would again wear off, and, before long, the operation would be repeated.

Some companies removed the first high spots themselves, before delivering the car, by running the engine with the bearings set up metal to metal until they began to smoke and then quickly stopped the engine just before the babbitt melted.

Accurate gaging methods soon indicated the trouble, and demands were made for more accurate machining. The precision boring machine, using a diamond tool, replaced the reamer, and everything was rosy for a while. The automotive engineer, however, always ready to take advantage of all developments, increased engine speeds until even the diamond-bored babbitt bearing failed. New bearing material had to be developed which did not lend itself readily to either die casting or centrifugal molding into the rod. These new bearings had to be made as separate shells and clamped into the large bore of the connecting rod. This meant that the steel rod must first be bored to very accurate tolerances to avoid any buckling of the thin bearing shell when it was inserted in the connecting rod. The engineers figured that the bores must not vary over 0.0005 in. to avoid selective assembly.

PRECISION BORING REPLACES GRINDING

At that time, boring steel to such tolerances was generally considered to be impracticable and many engine builders installed grinding machines for the final sizing operation in the rods. However, some experimented with high-speed steel, stellite, and, finally, cemented-carbide tools in the same precision boring machines that had formerly been used on babbitt. These tests showed that rigidity of spindle and holding fixture had much to do with tool life, and, as a result, a new design of spindle was developed and tried out. Today, the majority of connecting rods are finish-machined by this method.

The harder bearing metals that were developed have been so successful that now the crankshaft journals fail first. A higher degree of hardness is demanded, and several new processes for obtaining this are already in use. Local or surface hardening of all crankshaft bearings to between 58 and 60 on the Rockwell C scale is obtained without heating the entire forging. As the final finishing is by grinding, this new development should have little bearing on the grinding machines that were formerly used, but, since previous heat-treatment of the forging before machining is unnecessary, it will no doubt affect tool design and surface speeds and feeds for other operations.

In addition to the subjects mentioned in this paper, no list of machine-tool builders' outstanding contributions to the automotive industry would be complete without including those machines that drill or tap all the holes on five sides of a cylinder block in one operation; use broaches up to 80 in. long for surface broaching, finishing the top of cylinder blocks from the rough casting in one pass; weld steel water jackets on water-tight cast-iron cylinder blocks; and automatically perform various operations by hydraulic power under electrical control so that they appear human, plus many more developments too numerous to mention in this paper. The true facts behind these improvements are seldom made public, but they are as worthy of recognition as the thrilling stories re-enacted daily over the radio and probably as interesting.

Unknown at present to the automotive industry is a machine-tool development that will find a place in the building of automobiles at a not so distant date. This is the precision thread-grinding machine, which, until a few years ago, was considered a machine for use in finishing taps and thread gages; little consideration was given to it as a production machine. Strictly a precision machine, it is now finding its way into many fields remote from the gage and tap industry. Household washing-machine manufacturers find that worms finished on a precision thread-grinding machine are quiet and less likely to irritate the sensitive ears of the housewife. Hundreds of these worms are ground every day at an hourly production rate of 60 pieces per operator.

The primary consideration in airplane design is "pay load." Lessened weight of airships means more passengers carried with the same horsepower. One obvious way to reduce weight is to decrease the size of component parts, which can be accomplished by using materials having greater tensile strength. Increased strength generally means greater Brinell hardness which, in turn, decreases machinability. Steel of 400 Brinell hardness can be turned and bored with carbide-tipped tools with a fair degree of satisfaction, but the threads can best be produced by grinding.

Chasers for cutting threads on pipes show considerably more life when ground from the solid hardened high-speed-steel blanks. Contrary to general grinding practice, oil instead of water is used for coolant in these new precision production machines, and likewise startling is the fact that threads up to about 10 pitch can be ground from the solid blank in from two to four passes, holding the pitch and lead to a 0.0002-in. tolerance. Where and on what operation, these machines will make their debut in automobile factories will be interesting to observe.

Fundamentally, most machine processes are based on the same principles as in the days before the automotive industry came into prominence. However, that industry could never have attained its present size, if machine-tool builders had not developed machines capable of finishing parts within thousandths of an inch at production rates that run up to hundreds of pieces per hour. In the old days, finishing a piece to such accuracy was the work of the toolroom. Therefore, the greatest contribution of the machine-tool industry to the automotive industry would seem to be the development of high-production machines producing toolroom accuracy.

Recent Improvements in British Tools

MORE uniform hardening of twist drills has eliminated softness at the center, and polishing of the cutting flutes enables the tool to clear itself of chips readily, as they are broken up rapidly, and prevents clogging. Heat generated in the hole and at the drill point is thus dissipated more quickly, and danger of tool failure is also reduced.

Tooth strength of milling cutters has been increased, and a more extended use of staggered teeth has resulted in larger production. Variations of spiral and helix angles to meet special needs is practically the only improvement in design. Careful selection and heat-treatment of the steel used has produced greater toughness.

Combination tools are growing in importance. One of these is the double-diameter twist drill, in which the flutes are of one diameter for approximately half of their length and are stepped down to a smaller diameter for the remaining distance, thus permitting two different diameters of hole to be bored with the one tool. Other combination-type tools are a core drill and reamer, a spot facer and counterbore, and a collapsible tap. *The Times Trade & Engineering*, April, 1937, p. 34.

WELDED STEEL *in High-Speed* RAILROAD SERVICE

By EVERETT CHAPMAN

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HIGH-SPEED railroad service demands structures of light weight and high fatigue strength. These basic requirements have been adequately met with welded alloy steels. Two dangerous periods in the evolution of a high-duty, lightweight welded-steel structure are (*a*) the design and (*b*) the manufacture.

To reduce weight and still have a serviceable structure in the face of certain hypothesized load conditions, the designer must first choose a material that will enable him to work at higher stress levels than are usual with mild steels. "Serviceable" lightweight equipment imposes a further requirement that is by no means supplementary.

FIG. 1 USE OF FORGINGS AND GAS-CUT PLATES TO SCULPTURE HIGHLY LOADED MEMBERS INTO EASY CONTOURS

(This example is in the region of the main bearings of a 500-hp Diesel-engine frame. In highly loaded regions, every care should be taken to have the difference between maximum and average stresses small.)

The measure of serviceability is the ratio of the average stress level to the maximum stress, wherever it may occur. Hence, when lightening a structure by raising the design stresses in a suitable medium, great care and attention must be given to sculpturing of corners and contours. This is important in high-speed railroad service where the dynamic augment may exceed values given by experience at slower speeds. The use of higher-strength alloys working at higher stress levels does not by any means constitute an additional factor of safety, but, on the contrary, additional care should be taken to ease all boundary conditions where a change of direction is involved. Fig. 1 shows an application of this nature.

UNIFORM STRESS DISTRIBUTION MUST BE ATTAINED

Welded-steel designs should be scrutinized carefully with respect to details of the joints and boundary conditions. A welded-steel joint is either 100 per cent rigid or is broken. This is not so with the riveted joint, in which the rivets can lose their bearing without complete failure occurring. Complete rigidity of the welded joint is the seat of all the advantages and the cause of most of the troubles. It can, and will, transmit the full bending moment applied to it, making the structure truly continuous. Because of this, it must be capable of transmitting the full moment and under repeated applications. Every detail of the joint must be carefully scrutinized for stress concentrations. The technique of making a joint exhibiting a uniform stress distribution must be thoroughly and rigidly defined for the fabricating shop. This is very often one of the controlling factors of the design. For instance, a completely closed box section cannot be butt welded satisfactorily to another completely closed box section so as to develop the full areas involved for a pulsating load, because the back of the weld cannot be treated to eliminate the unfused root of the weld made from the outside. Some ingenuity is necessary in this case.

Considerable thought must be given to selecting proper structural shapes which will best adapt themselves to the imposed load. In this respect, the designer will find welded-steel construction to be the most flexible and pliant medium that he has at his command, since no serious limitations of shape or wall sections are encountered. For a member whose load is predominantly torsion, the tube is immediately available; if a load is chiefly bending, I or rectangular box sections are available. If the tube and the rectangular box must intersect, a transition casting or a pressed member that is nicely shaped to effect gradual changes of contour can economically serve as the joining member.

A common mistake in design is selecting the wrong shape for the imposed load. For instance, a channel section for twist is a poor choice, and attempts to proportion this channel for torque result in a mathematical fiasco. The channel can transmit torque, but it is the wrong choice for such a load on two counts: (*a*) The average designer does not know how to calculate the maximum stress in such a twisted member, has no idea of how it acts, and flounders around in a maze of misapplied polar moments of inertia; and (*b*) it is not the most economical member or section to transmit torque.

Another illustration of the same thing is the tendency to tie a load to its reaction in seemingly the most indirect manner possible. Certainly, the lightest member is one acting in pure tension, and a member in pure tension can be calculated by more people than can calculate one that curves and wanders about and has all sorts of odd little eccentricities in it. True enough, we sometimes have to use a C-frame to meet some

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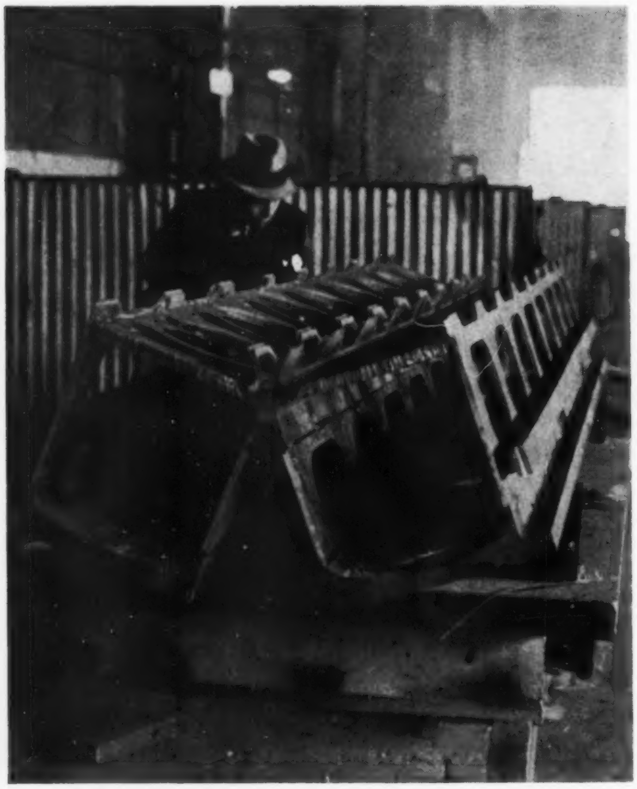

FIG. 2 TOP-DECK STRUCTURE AND SIDE PLATES OF A 1500-HP DIESEL ENGINE

(The gas load is carried in straight lines from the top deck through the side plates and the transition member, which is shown in place after machining and before welding, to the crankshaft which is the common reaction point for all cylinders.)

space requirements, but even so, in the interests of light weight, the throat should be as small as practicable. An example of this thought of keeping steel in straight tension so that the force can be calculated and the designer may know more about how it is acting is shown in Fig. 2. This illustration shows the top-deck and side-plate structure of a 1500-hp Diesel engine together with a transition member. Here, the gas load in each bank of cylinders must be transmitted to the common reaction point, the crankshaft. The minimum weight of steel to transmit this load safely will result when the gas load and the crankshaft are connected by straight lines. At the intersection of the two inner members, a contour change needs special attention since the presence of one constitutes an excrescence on the other and we may reasonably look for a nonuniform stress distribution. Gentle curves sloping into one another ease the maximum-stress value immensely. This blending of one into the other is accomplished by a machined member serving as a transition piece at the critical point. Fig. 3 shows another type of Diesel main-frame member. Once, the ideal shape has been worked into the design, the stresses can be confidently calculated and run to a fairly high value.

UNDISCOVERED CRACKS ARE A GREAT HAZARD OF MANUFACTURE

One of the greatest hazards while the piece is being welded is the possibility of cracks that are undiscovered and remain in the finished structure when it goes to work. Steel and heat in combination can produce unbelievable results and the combination in the case of a welded structure can be most disturbing. The distinguishing feature of a weld is that localized application of heat always results in severe temperature gradients. This means two things: (*a*) rapid flow of heat from one place to another or quenching, and (*b*) thermal stresses are produced which do not vanish as temperature equilibrium is established. Thermal expansion and contraction is a reversible phenomenon only when temperature is uniform.

Quenching parent metal by rapid flow of heat from the hot zone around the weld to the colder ones away from it is to be considered hazardous only if the nature of the parent metal is such that it will harden. Hardenability is, of course, a function of the same variables as high strength; namely, carbon content and, to a lesser degree, alloy content. Thus, the steelmaker when asked to produce high-strength welding steels is immediately faced with the problem of producing high physical values at low carbon contents. Many interesting solutions of this problem have been made during the last five years. Some were admirable, and some tried to overcome this basic welding axiom by mixing wish thinking with carbon. Unfortunately, and as usual, nature paid no attention to this type of solution.

One of the best steels is the low-carbon manganese-molybdenum type with 0.18 per cent of carbon representing the maximum content that will be trouble-free. While its physical properties at low carbon contents are not as high as some of its contemporaries, it is one of the most foolproof, dependable steels on the list and welds beautifully. When considering the manufacture of alloy steel with this low carbon content, the nature of the alloys must be such that they can be introduced in the steel without oxidizing. Otherwise, the steel will be excessively dirty and laminated, a condition that makes it unusable in a welded structure since, contrary to a riveted structure where the rivets work in shear against the entire cross section of the plate, the steel can be loaded in three directions. This excessive dirtiness in the case of improperly chosen alloys for low carbon ranges is due to the fact that the open-hearth mechanism which reduces the carbon in the bath is one of oxidation. By the time the carbon is down to 0.10 or 0.12 per cent, the bath is highly oxidized, and great care must be used in the technique of cleaning up the bath and in the choice of the alloy additions.

Manganese-molybdenum steel seems to be a satisfactory compromise between all factors to be considered. High physical properties are by no means the only defining characteristic of a steel for lightweight high-duty structures. A 75,000-lb steel that is able to survive the ordeal by design and fabrication and enter service uncracked seems far better than a 100,000-lb steel with a crack in it. Initial local hardening due to the cold parent-metal quench would not cause fabrication cracks in the welded structure were it not for the stresses that are set up during welding by this same heat which causes hardening.

FAR-REACHING EFFECTS OF THERMAL EXPANSION AND CONTRACTION

The phenomenon of thermal expansion and contraction being nonreversible in the case of nonuniform temperature distribution is an interesting one and has far-reaching consequences in a welded structure. These resultant stresses can be easily equal to the yield point of the metal, and, further, the system of stresses can be such that the apparent or working ductility of the steel is reduced to 10 per cent of the tensile-test value. The irreversibility results from the fact that the steel is not the same shape after it cools as it was before it was heated. The seat of this irreversibility under nonuniform heating is that the cold portion of the configuration acts to constrain rigidly expansion of the heated portion. At some point in the region where the temperature gradient is high, the yield point of the material is exceeded. A plastic deformation occurs, and the

hotter metal will upset, becoming thicker and shorter than it was with reference to the initial temperature. As the piece cools, this shorter and thicker region now pulls against the initial constraining portion, and, in the final state of temperature equilibrium, a complex two-dimensional state of internal locked stress exists. Its severity is a function of the initial-temperature gradients and the adjacent rigidity. This mechanism can be illustrated as shown in Fig. 4. Suppose a plug is tightly fitted in a hole in a steel disk as shown in the drawing at the top and is heated by passing an electric current through it. The diameter of the plug tends to increase but its free expansion is constrained by the disk. If it is hot enough, it will assume the shape shown in the drawing at the lower left. The result after plug and disk have cooled to room temperature is illustrated in the lower right corner. The former is now a loose fit in the hole by a few thousandths of an inch. In the actual case under discussion, this looseness of fit would have to be made up by elastic strains in the plug and disk, and severe stresses would exist.

If the steel is hardenable, a highly quenched nonductile zone will exist in the neighborhood of these heat stresses, and, more than likely, a crack will occur under these conditions. These fabricating cracks are difficult to locate and repair and may exist in the finished structure where they are a source of failure under fatigue load. A good example of this is the building up of journals by welding. A 0.50 per cent carbon-steel axle requires careful and involved welding technique if it is to be welded without the production of many fine microscopic cracks. Experience has shown that these axles should not be entrusted to the technique of the average shop.

The phenomena just outlined are reasons why every welded-steel structure for high duty should be heat-treated in a proper furnace before it goes into service. The temperature should be high enough to restore some ductility to the hardened zones, and the time in the furnace should be long enough to allow the internal stresses to readjust themselves. It is a twofold treatment. Attaining a certain temperature throughout the piece to break down the hardened constituents is not enough. Readjustment of the total structure to eliminate or minimize residual stresses is a phenomenon of creep. Sufficient time at the stress-relieving temperature must be allowed for the material to flow. Temperatures of 1200 F have been found to be adequate while 2 hr per in. of maximum thickness seems to remove all residual stresses of practical consequence. Behavior of the welded structure while it is being machined is a good indication of the state of stress. A squirming structure is not free from stresses. The treatment mentioned seems to deaden most structures for the machining operation.

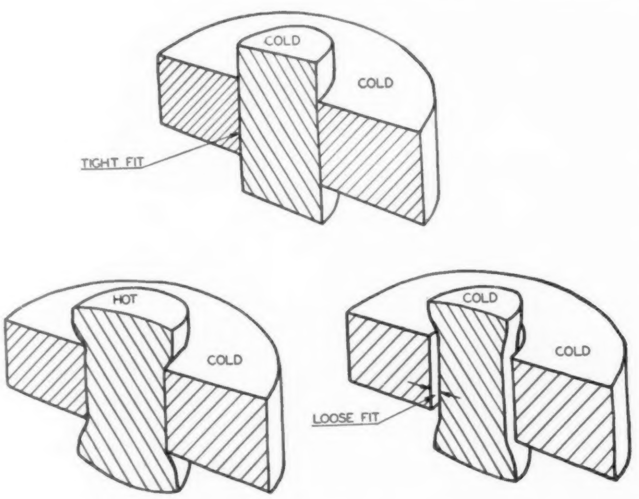

FIG. 4 SCHEMATIC REPRESENTATION OF THE ACTION OF THERMAL GRADIENTS IN SETTING UP LOCKED STRESSES

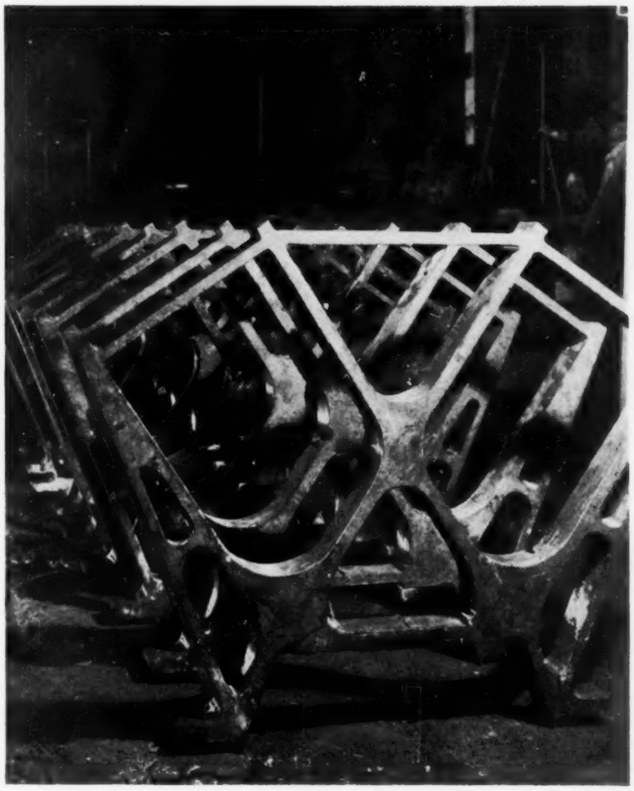

FIG. 3 MAIN-FRAME MEMBERS FOR A 1200-HP DIESEL ENGINE

(These members were cut from a high-strength alloy-steel plate with an oxyacetylene torch which enabled the designer to sculpture their shape. This illustration shows that welded-steel construction is not necessarily angular and slat-like.)

TWO-DIMENSIONAL EFFECT OF THERMAL STRESSES

The two-dimensional nature of thermal stresses in flat plates may have serious consequences. The stresses exist in two directions because the temperature gradient existed in two dimensions. If the locked-stress system assumes a biaxial-tension form, ductile properties of the steel are almost completely inoperative as a corrective mechanism. The second set of tensile forces at right angles to the first inhibit the normal lateral contraction of the steel as expressed by Poisson's ratio, and, under these conditions, shearing action cannot take place. The steel shows an apparent ductility of about 6 per cent. A practical case where this mechanism actually causes failure occurs in the bending of long thick plates for pressure-vessel shells. A piece of good steel of 3 × 3 in. cross section will bend easily around a 6-in. pin through 180 deg. If a section is cut through the portion of greatest ductility, the 3-in. square will now appear as a trapezoid, the tension side having contracted and the compression side expanded laterally. Lateral deformation has not been inhibited. If a piece of the same steel 120 in. square and 3 in. thick is bent in a bending roll to form a shell, the steel will break at an elongation corresponding to about 6 per cent, in contrast to the exhibition of ductility of about 30 per cent in the small specimen. This is due to inhibition of lateral deformation by the remainder of the plate outside the bend line. These shells must be bent either hot or in a series of small arcs

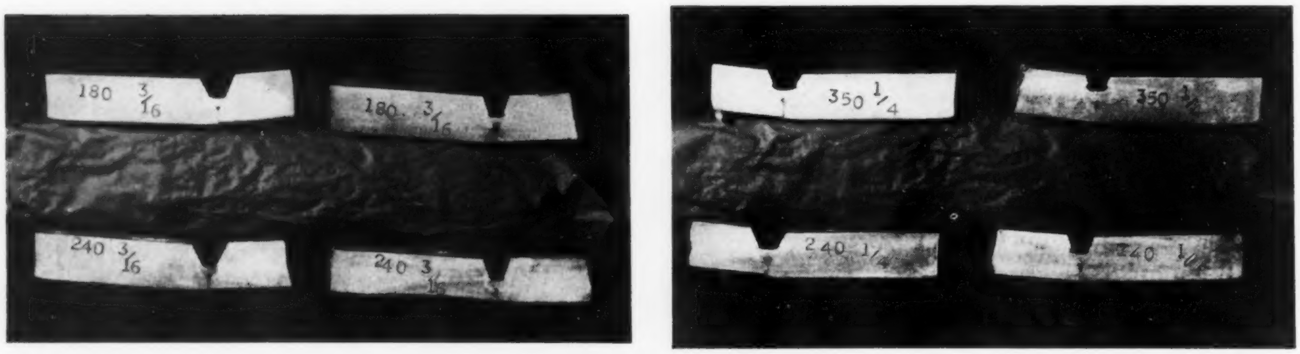

FIG. 5 CONDITIONS AT THE ROOT OF WELDS
(These are the result of using various rod sizes and currents at different angles.)

whose incremental change does not represent a plastic stretch of more than about 5 per cent.

In a welded joint, the combination of hardened zones and odd thermal-stress systems may have a third inherent evil present to insure that the joint will not withstand fabrication stresses or a fatigue load in service. The root of a weld, where the first bead was deposited, is difficult to fuse thoroughly. The beveled groove is an acute angle, and the molten pool freezes before it can melt the sides near the bottom. As a result, an internal crack is formed in the interior of the weld, which is that portion of the boundaries of the two original plates that were not fused together when the joint is integrated with the arc. These unfused boundaries form internal discontinuities that may be very abrupt and sharp. Fig. 5 shows several attempts with various currents, rod sizes, and angles to eliminate the root crack by complete fusion. Only the initial bead has been deposited since it is the bead in question. The results are not usable. To make a butt joint with no internal crack, necessitates chipping from the back into the first bead and then resealing the groove with a weld from the side that was chipped. Such a butt joint will exhibit properties under any kind of load that may be imposed which are equal to, or better than, the parent metal.

Caution must be observed in using fillet welds since they have a large unfused root. Fig. 6 shows photoelastically the stress distribution around a fillet weld that is loaded axially. The internal boundary is a potential rip that will easily propagate itself through the throat of the welds under fatigue. Fillet welds in fatigue service should only be used in shear, and, even then, attention must be paid to the ends of the weld where shear concentrations exist.

If the basic principles that have been outlined are combined with good designing practice, welded-steel structures can be evolved that are lighter than conventional construction. Service records of various pieces of equipment to date have fully justified use of welded alloy steels.

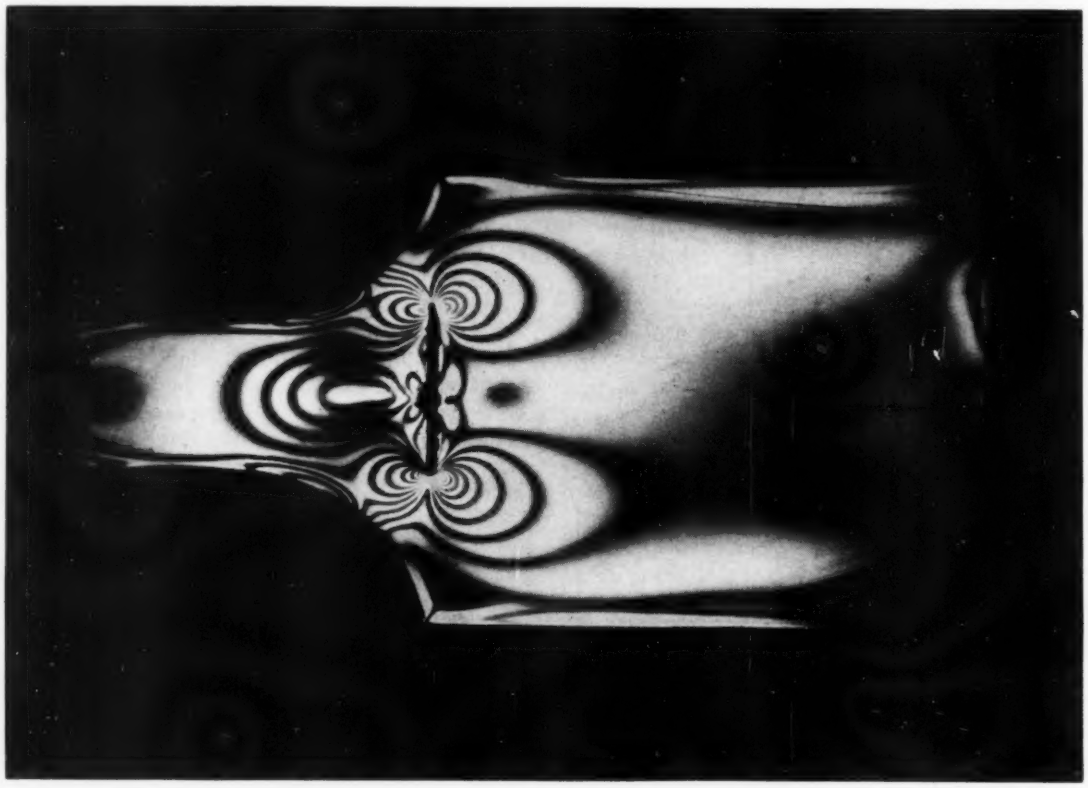

FIG. 6 PHOTOELASTIC ILLUSTRATION OF STRESS DISTRIBUTION AROUND FILLET WELDS

Effective Use *of* METAL-CUTTING TOOLS

By R. C. DEALE

E. W. BLISS COMPANY, BROOKLYN, N. Y.

THIS PAPER is a résumé of studies and experiments carried on by the Subcommittee on Metal-Cutting Data of the A.S.M.E. Special Research Committee on Cutting of Metals. This work has had as its objective determination of factors governing effective use of single-nose metal-cutting tools, such as are used in lathes, planers, shapers, and other machine tools and to indicate a method for correlating these factors to effect great economies in machine-shop practice as compared with present methods. Among the factors considered are tool form, tool material, method of heat-treatment, material machined, depth of cut, rate of feed, cutting speed, and tool life. Formulas have been developed covering many of these factors, and standard practice established for others that are not susceptible of mathematical analysis.

NEW METHOD EFFECTS ANNUAL SAVING OF $300,000

As an instance of the savings possible through the application of some of the methods developed, results of a change in the procedure for hardening high-speed steel tools in a large machine shop may be cited. Six tools hardened according to the procedure previously used in this shop were tested against six identical tools hardened by a method that was developed by this committee from experiments carried on at the National Bureau of Standards, which involved changes in the temperature and time used. A sufficient number of tests were run with each set of tools on billets made from two different grades of cast iron to obtain approximately 20 test points for each heat-treatment method. Tests were run under uniform conditions of depth of cut and feed, and the time required to break down the cutting edge of the tool in each test was determined. The cutting speed for uniform tool life was calculated by the formula, established by the work of the committee

$$VM^{0.100} = \text{a constant} \qquad [1]$$

where

M = tool life, min
V = cutting speed, fpm

Tools that were hardened according to the Bureau of Standards method, under uniform conditions of tool form, depth of cut, rate of feed, metal removed, and tool life, could be run at cutting speeds approximately 20 per cent higher than those hardened according to the usual shop methods. The resultant gain in production could be obtained at no additional cost, as the equipment used both for hardening and utilization of the tools was unchanged. The estimated possible savings in this particular shop resulting from the higher speeds are approximately $300,000 per year, and this shop was considered to be one using advanced practices. Work of the committee has indicated that proportionate savings are possible in the average shop by similar attention to proper selection of tool material, its heat-treatment, contour of tool, and proper correlation of these to the rate of feed, depth of cut, material machined, tool life under cut, and cutting speed.

The committee began its work with a careful study of the data presented by Frederick W. Taylor in his classic paper, "On the Art of Cutting Metals." In addition, all available published data on the cutting of metals, including papers published in the United States, England, Germany, and Sweden were studied, together with many unpublished data from the files of outstanding industrial organizations in the United States. These studies were supplemented by extensive experiments that were carried on by the committee at Stevens Institute of Technology, on the cutting of steel and cast iron in a powerful lathe with high-speed steel tools. This experimental work permitted the coordination of the data previously obtained and the filling of gaps in the work of other investigators.

CUTTING-SPEED AND OTHER FORMULAS DEVELOPED

Some of the more fundamental relations developed are as follows, of which the cutting-speed formula is undoubtedly the most useful

$$V = \frac{K_1 \times K_2 \times K_3 \times K_4 \times K_5 \times K_6 \times K_7}{T^a \times L^{bT} \times M^n} \qquad [2]$$

where

- a = exponent, determined experimentally, depending on metal cut, regardless of tool material
- b = exponent, determined experimentally, depending solely on tool material
- K_1 = constant, determined experimentally, depending on the tool material
- K_2 = constant depending on the hardening treatment of a steel tool. For tools not given any heat-treatment, such as Stellite and cemented carbides, this term drops out
- K_3 = constant depending on tempering treatment of a steel tool. This term also drops out for Stellite and cemented-carbide tools
- K_4 = constant depending on machinability of metal cut
- K_5 = factor depending on kind and quantity of cutting fluid used
- K_6 = factor depending on rake angle of tool
- K_7 = factor depending on type of cut, such as roughing, finishing, parting, forming, and the like
- L = total active length of the cutting edge of the tool in contact with the work, in.
- M = tool life to complete failure, min. This includes only the time when tool is actively engaged in removing a chip from the workpiece up to point of failure, which will vary according to practical shop requirements of a given operation
- n = exponent, determined experimentally, depending on tool material, metal cut, and type of tool failure
- T = average chip thickness, in. Where the tool has a nose radius, or where the point angle is appreciably greater than 90 deg, this is equal to chip area divided by total length of engagement. When the point angle is 90 deg or less, average chip thickness may be taken as equal to chip

Contributed by the Special Research Committee on Cutting of Metals and presented at the Semi-Annual Meeting, Detroit, Mich., May 17–21, 1937, of The American Society of Mechanical Engineers.

area divided by active length of front cutting edge

V = cutting speed, fpm, measured on the uncut section of the work ahead of the tool.

All available experimental data have been analyzed in developing this formula. Deviations between values computed by the formula and those obtained experimentally range from 3 to 8 per cent, which is believed to be within the limits of experimental error. This formula has been used in checking a number of shop operations and gave results within 5 to 10 per cent of those in practical use, a degree of accuracy which is ample for any ordinary machining operation.

Values have been determined from experimental data for these various exponents, covering the use of all tool materials now (1937) in general use for cutting steel and cast iron. Such data as are available indicate that both constants and exponents change whenever the character of the metal cut changes, as from steel to bronze. Lack of adequate experimental data has made impossible at this time the setting of values for constants that would make this formula applicable to the cutting of nonferrous metals. Some experiments covering cutting of monel metal have indicated that the same form of formula applies with reasonable accuracy to cutting this metal. For heavy roughing cuts in steel with chip thickness greater than 0.015 in. and without a cutting fluid, using well-hardened high-speed steel tools of the commonly used 18-4-1 type, this formula becomes

$$V = \frac{K_4}{T^{0.67}\,L^{2.37}\,M^{0.125}} \qquad [3]$$

For calculating the tangential component of the cutting pressure a formula has been developed, which makes it possible to calculate the power required to remove a given chip. This formula is

$$P = K_8\,K_9\,T^c\,L^d \qquad [4]$$

where

c and d = exponents, determined experimentally, which are dependent on the metal cut

K_8 = constant, determined experimentally, which is a property of the metal cut

K_9 = constant, depending on rake angle of a tool, measured in direction of chip flow

P = component of pressure exerted on tool by a chip, in a direction tangential to the surface cut, lb

For cutting steel, formula [4] becomes

$$P = K_8\,(1 - 0.0075R)\,T^{0.78}\,L^{1.1} \qquad [5]$$

where

R = rake angle, deg, measured in direction of chip flow

An attempt has been made to develop similar formulas for normal and longitudinal components of chip pressure, but lack of adequate data has made this impracticable up to the present.

A formula has been developed for calculating the interval at which a tool should be reground to give minimum overall machining costs. For rough turning steel with high-speed steel tools, total cost of operating machine tool during cutting period between grinds equals seven times total cost of changing and grinding a tool, including tool cost per grind.

Data have been obtained on the breaking strength and deflection of hardened high-speed steel, and an attempt is being made to develop formulas to calculate the safe load on a tool, or its deflection under a given chip.

These formulas make possible the determination, with a degree of precision sufficient for ordinary shop practice, of the effect of tool contour and chip proportions on the cutting speed that can be used and that should be used under given conditions. Power required to remove a given chip can also be determined.

MOST ECONOMICAL FEED, SPEED, AND DEPTH OF CUT

Application of these formulas and study of the data gathered by the committee have made possible the preparation of tables showing the most economical combination of feed, speed, and depth of cut for any tool shape when cutting practically any type of ferrous material and horsepower required at the nose of the tool to remove the chip but not including losses in the drive of the machine tool. When proper constants are applied to the data in these tables, feed, speed, and depth of cut for more than 300 hundred different steels and cast irons, can be determined.

As an illustration in the use of these tables, take the following examples:

What speed should be used in cutting S.A.E. No. 1020 hot-rolled steel with a high-speed steel tool of the usual 18-4-1 analysis, having a $^1/_8$-in. nose radius, 30-deg side cutting-edge angle, 14-deg side rake, and 8-deg back rake, for a cut $^1/_4$ in. deep and $^1/_{32}$-in. feed? What power will be required? What will be the effect of changing the feed to 0.008 in.?

From the table, the following information is obtained: Cutting speed for a cut $^1/_4$ in. deep with a $^1/_{32}$-in. feed is 89 fpm; power required is 5.4 hp; and metal removed is 8.3 cu in. per min. With 0.008-in. feed, cutting speed becomes 208 fpm; power required is 4.3 hp; and metal removed is 5.0 cu in. per min. Thus, metal can be removed 66 per cent faster with a given tool with the $^1/_{32}$-in. feed than with the 0.008-in. feed, when the tool is run to the limit of its capacity in each case.

What is the cutting speed and power required for a $^1/_4$-in. cut and $^1/_{32}$-in. feed with the same tool when cutting S.A.E. No. 1040 steel heat-treated to give a tensile strength of 113,000 lb per sq in., a yield point of 83,000 lb per sq in., and elongation of 19 per cent in 2 in., a reduction in area of 49 per cent, and a Brinell hardness of 230?

From tables, cutting speed for a $^1/_4$-in. depth of cut and $^1/_{32}$-in. feed is found to be 89 fpm; power required is 5.4 hp; and multipliers for S.A.E. No. 1040 steel of the characteristics given are speed, 0.43; and power, 0.55. The cutting speed, depth of cut of $^1/_4$ in. and feed of $^1/_{32}$ in. is 0.43 × 89 fpm = 38 fpm, and power required is 0.55 × 5.4 hp = 3.0 hp. Similarly, values for any conditions, for which tables are not already available, can be calculated.

RESULTS BY FORMULA CHECK WITH MACHINE-SHOP PRACTICE

Effect of cutting fluid on the speed with which a given cut may be taken may also be determined by application of a constant from a table. An illustration of the accuracy with which data calculated by formula [2] check with good shop practice may be interesting. A face-milling cutter 14 in. in diameter with 18 sharp-cornered teeth was used to take a surfacing cut $^1/_2$ in. deep on a large steel casting with a feed of $1^1/_2$ in. per min at a speed of 16 rpm and using about $^1/_2$ gpm of 20 to 1 soluble oil as cutting fluid.

Serious chatter resulted and depth of cut was reduced to $^3/_8$ in.; feed was increased to $5^1/_2$ in. per min; and speed was reduced to 14 rpm. Chatter was eliminated by these changed

(*Continued on page 448*)

LUBRICANTS *and False* BRINELLING *of* BALL *and* ROLLER BEARINGS

By J. O. ALMEN

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IN SPITE of rough usage from high speed, overloads, and infrequent lubrication, ball and roller bearings in automobiles and trucks give little trouble in service. Automobiles will travel tens of thousands of miles without measurable wear of their antifriction bearings, yet these same bearings are often seriously damaged while the automobile is stationary during shipment in freight cars and on trucks. The bearing damage occurring in shipment consists of indentations in the bearing raceways opposite each of the balls or rollers on the loaded side of the bearings. These indentations have the appearance of having been produced by extremely high pressures, and, therefore, the bearings are erroneously said to be "brinelled."

Bearing damage of this type is not confined to automobile road-wheel bearings in freight-car shipments. It has given trouble in installations of many antifriction bearings that are normally at rest and are used mainly to avoid static friction or where the bearings move through small angles. Among these are automobile spring shackles, kingpin bearings and other steering-gear parts. In aircraft engines, valve-rocker-arm bearings have, until recently, been subject to this form of damage. Bearings in variable-pitch propellers and control parts have, at times, been so badly damaged as to become inoperative and even the landing-wheel bearings are damaged in flight. In fact, an assembled bearing can be ruined merely by placing it on a vibrating plate.

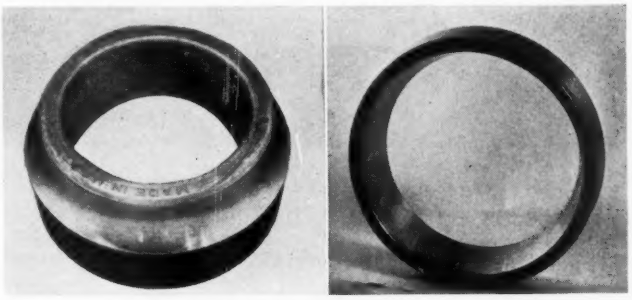

FIG. 1 EXAMPLES OF (LEFT) BALL TYPE AND (RIGHT) ROLLER TYPE AUTOMOBILE-WHEEL BEARINGS INDENTED IN SHIPMENT

TYPICAL EXAMPLES OF BEARING INDENTATIONS

Fig. 1 shows two front-wheel bearing races that have indentations resulting from small-amplitude oscillations of the wheels due to vibrations of the freight car in which the automobiles were shipped. The race at the left is from a ball bearing and that at the right is from a roller bearing. Actual indentations in both cases are small, the width of the marks being more a measure of the amplitude of the wheel oscillations than a measure of their depth.

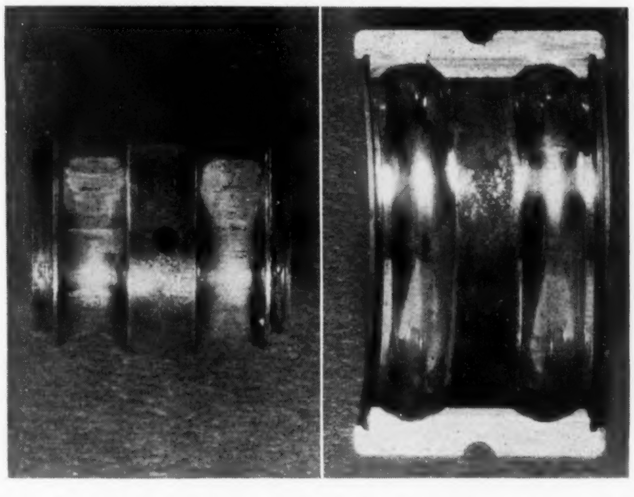

FIG. 2 AIRCRAFT-ENGINE ROCKER SHAFT BEARING THAT WAS DAMAGED IN SERVICE BY ENGINE VIBRATION

The inner and outer races of an aircraft-engine valve-rocker bearing are pictured in Fig. 2. Here, the number of indentations is larger than the number of balls in the bearing due to shifting of the ball cage relative to the races. These deep indentations were formed in periods of rest between valve opening and closing when the bearing carried practically no load but was vibrated severely by the engine. This trouble has been practically eliminated by substituting oil for the grease lubrication previously used.

Fig. 3 shows the main thrust-bearing race and rollers from a variable-pitch airplane propeller. This bearing moves through a small angle in adjusting of the propeller-blade pitch but is stationary most of the time except for the vibrations from the blade and the engine crankshaft. The actual damage

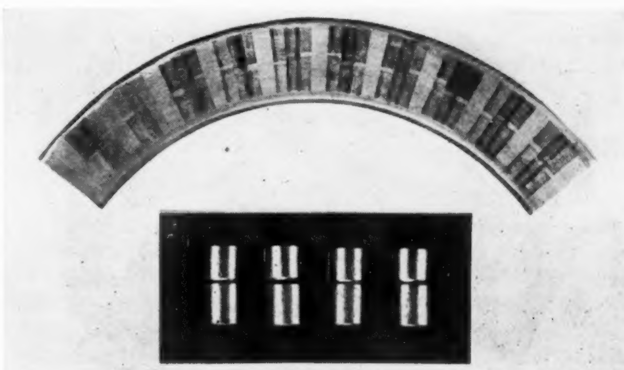

FIG. 3 MAIN THRUST BEARING OF A VARIABLE-PITCH AIRPLANE PROPELLER

Presented at a meeting of the Chicago Section, Chicago, Ill., Oct. 13, 1936, of The American Society of Mechanical Engineers.

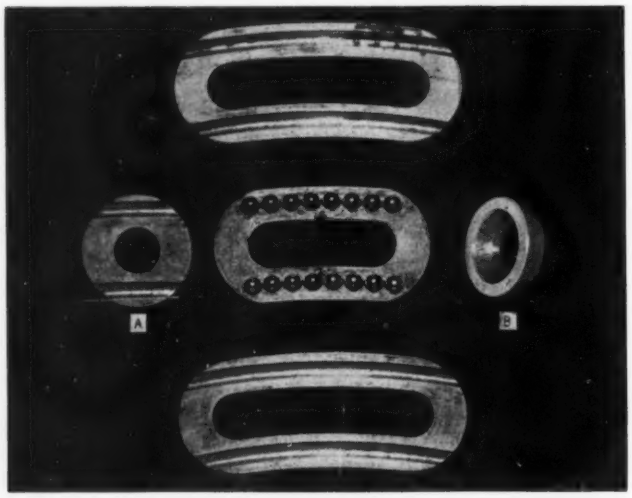

FIG. 4 EXAMPLE OF SEVERE INDENTATION IN THE CONTROL PARTS OF A VARIABLE-PITCH AIRPLANE PROPELLER

is again less than appears from the illustration but is still sufficient to be troublesome.

Severe indentations that occurred in the control parts of a variable-pitch airplane propeller are illustrated in Fig. 4. The load on these parts is relatively low, but vibration is severe. Of especial interest in this group, is the small part at the middle left, with the reverse side at the middle right. This part pivoted on a conical-headed bolt, and some movement occurred between the bolt head and the conical seat, which was deeply corroded as a result.

Fig. 5 shows part of a needle-bearing automobile universal joint that was badly indented while operating in a laboratory test fixture. This specimen transmitted 45 hp at 1000 rpm for 200 hr. The shafts were in direct alignment and, therefore, the movements at the needle bearings were limited to errors in the setup and to deflections of shafts and supports under load. Another test was made with the propeller shaft 1.5 in. out of alignment, in which case, the bearings were found to be only slightly indented. In a third test, with the shaft 2.5 in. out of alignment, three of the bearings were undamaged, and the fourth but slightly marked. These results agree with service experience for propeller shafts with various alignments.

In all cases of bearing indentation just enumerated, the fact that the bearings are at rest or have periods of rest and also that vibration is present should be noted. Bearings need not be heavily loaded to produce indentations, although, in general, the greater the load the greater the damage; however, under certain experimental conditions, decreasing damage with increasing load can be shown. Characteristic of indented bearings is a rust accumulation in the vicinity of the damaged area. In practice, this rust is not often observed because rotation of the bearing after a period of vibration quickly mixes the rust with the oil or grease used for lubrication.

BRINELLING A FORM OF WEAR

Since this brinelling of ball and roller bearings may occur under conditions of load that are much too low to cause true brinelling, it is clearly not a case of pressure indentation but comes under the general classification of wear. Many experimenters have noticed wear of this type, it being mentioned by E. M. Eden, W. N. Rose, and F. L. Cunningham[1] as early as 1911. Various explanations of its cause have been suggested from time to time. Several of the theories and supporting data presented by earlier investigators are of interest as pertaining to the special case of wear with which we are here concerned.

G. A. Tomlinson,[2] experimenting with the friction of small balls on steel plates, produced oxidation similar to that which occurs in ball and roller bearings. After considering such possible effects as electrolysis, adsorbed moisture, and local heating, he concluded that the damage was caused by tangentially acting cohesive forces lifting out metal particles which were so small that they oxidize instantly. In support of this theory of molecular cohesion, he offers an experiment that can be performed easily. Carefully clean a piece of plate glass and the surface of a fused glass bead which is attached to a light rod. If the rod be lightly poised in the fingers and allowed to stroke the plate, a series of snatches is felt as the bead "welds" and breaks away from the plate. (His use of the word weld should be noted particularly.) Examining this plate with a lens will reveal that even the lightest touch of the bead to the plate will produce scored dotted lines. Continuing this same experiment with hardened steel surfaces, the sensation of snatching, as the weld is made, is much less marked. Again, examination with a lens will reveal the path by the presence of a thin track of reddish-brown oxide. According to Tomlinson, steel, glass, stellite, and agate all produce the same effect on steel.

Dr. M. Fink,[3] experimenting with an Amsler wear-testing machine, reached the conclusion that wear of the type under discussion is the result of the formation and rubbing off of successive oxide films. The Amsler machine used in these tests consisted of two circular disks geared together to rotate at the same angular velocity and making contact on their peripheries as shown in Fig. 6. By making the disks of different diameters, relative slip of 1 per cent was obtained. The disks used by Fink were 10 mm (0.3937 in.) wide and 40 mm (1.5748 in.) in diameter and ran at 250 rpm under a load of 110 lb. In one case, after running in air for 50,000 revolutions, the loss in weight of one disk was found to be 0.1802 g (0.006356 oz). When this test was repeated in an atmosphere of nitrogen,

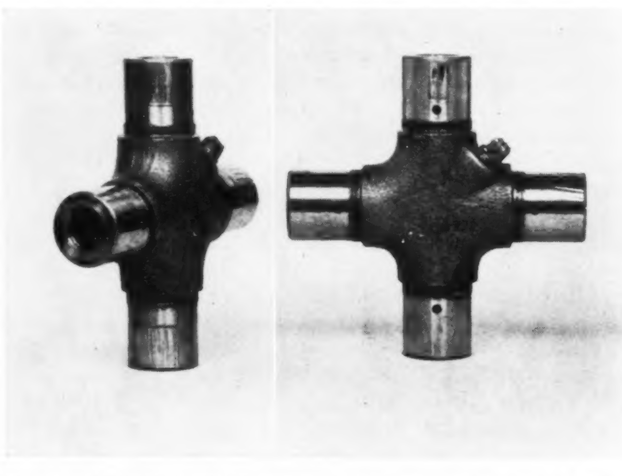

FIG. 5 UNIVERSAL-JOINT SPIDER THAT WAS DAMAGED WHILE OPERATING IN A LABORATORY TEST FIXTURE

[1] "The Endurance of Metals," by E. M. Eden, W. N. Rose, and F. L. Cunningham, Proceedings of the Institution of Mechanical Engineers, 1911, p. 875.

[2] "The Rusting of Steel Surfaces in Contact," by G. A. Tomlinson, Proceedings of the Royal Society of London, series A, vol. 115, 1927, pp. 472–483.

[3] "Wear Oxidation, a New Component of Wear," by Dr. M. Fink, Transactions of the American Society for Steel Treating, vol. 18, 1930, pp. 1026–1034.

no wear occurred. He also noted that, when test specimens were run in oxygen-free atmosphere, the rubbing friction was only one third as great as when they were run in air and that the surface became smooth and bright in contrast to those tested in air which were discolored with oxide films. As a result of these experiments, Fink concluded that oxidation is not a secondary effect, as stated by Tomlinson, but is an essential component of wear. According to Fink, lubricants do not protect the rubbing surfaces against wear oxidation, because they contain dissolved oxygen in sufficient quantity to produce this form of wear.

In 1934, S. J. Rosenberg and L. Jordan[4] of the National Bureau of Standards attempted to duplicate the experiments of Fink, using a similar machine and test conditions. They conducted tests in air and in atmospheres of nitrogen and hydrogen but used a relative slip between their test specimens of 10 per cent instead of 1 per cent as Fink did. Results obtained from these tests were not in agreement with the Fink tests. No appreciable difference was found in the wear, in air and in an oxygen-free atmosphere of nitrogen or hydrogen, of steel specimens having metallurgical characteristics similar to the Fink specimens.

In a discussion of Rosenberg and Jordan tests, Fink says:[5]

> The tests of Rosenberg and Jordan cannot be said to duplicate the tests of Fink since the occurrence of oxidation in their tests is an indication that oxygen-free atmosphere was not used in the cell.
>
> The use of 10 per cent slip is too great for the softer materials, since, in this case, the component of the removal of metallic particles predominates. . . . In the case of wheels running on rails, a maximum slip of about 5 per cent occurs.
>
> The field of friction oxidation is concerned with rolling friction with proportionately large surface pressures and small degrees of slip, 50 to 150 kg (110.23 to 330.69 lb) and 0 to 4 per cent slip. With sliding friction, the field of friction oxidation is concerned with 100 per cent slip and low surface pressures, approximately 0.5 kg per sq cm (7.21 lb per sq in.), thus presupposing unhardened material.
>
> Oil does not protect against friction oxidation since oxygen is dissolved in the oil.

Probably, the conclusions reached by all these investigators were justified within the limitations of their tests. The apparent contradictions of test results are no greater than have occurred in many other lines of research and can be explained by the differences in test conditions. A similar situation occurred a few years ago in regard to tests of extreme-pressure lubricants. In this case, S. A. McKee, E. A. Harrington, and T. R. McKee[6] of the National Bureau of Standards conducted comparative tests and obtained widely different results for each of four test machines. They, therefore, built another machine from which a fifth set of results was obtained. Differences between the five machines were the relationship of such variables as rubbing speed, heat dissipation, specimen hardness, specimen finish, and rate of load application. Since the lubricants under test were primarily intended to lubricate automobile rear-axle gears, the important point was to determine the relative merit of lubricants in rear axles in which the relationship of the variables was not the same as in any of the laboratory test machines. The real problem was to determine which of the machines most nearly graded the

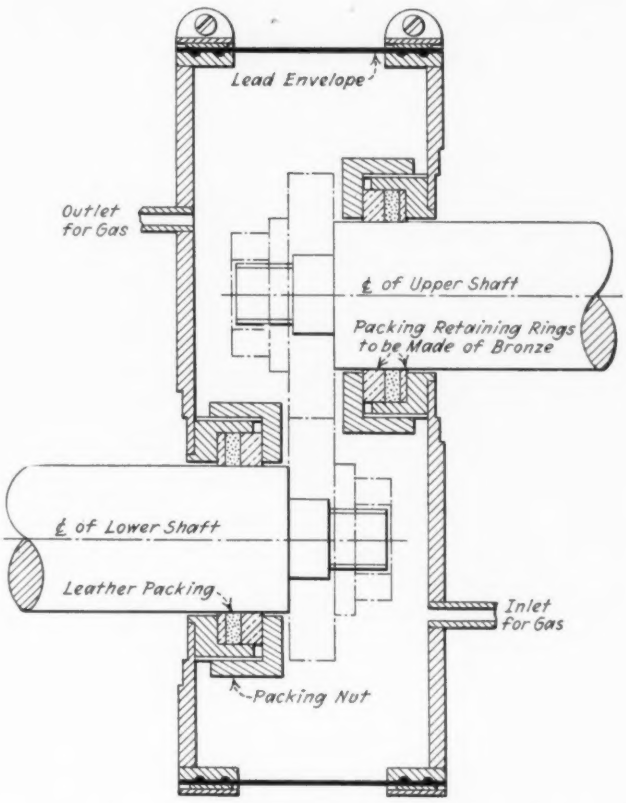

FIG. 6 AMSLER WEAR-TEST MACHINE USED BY DR. FINK IN HIS TESTS ON WEAR OXIDATION

lubricants in the order that these lubricants were graded by automobile rear axles in service.

These tests are mentioned merely to emphasize the difficulty of interpreting laboratory-test data. The conditions prevailing in practice can rarely be reproduced or even approximated in the laboratory, and first determining what happens in service and then varying the laboratory test procedure or equipment until results are obtained that are similar to those found in service is, therefore, of utmost importance in industrial work.

When the results obtained by Tomlinson, Fink, and the National Bureau of Standards are compared with the brinelling of ball and roller bearings in service, Fink's theory of wear oxidation appears to meet most nearly the requirements. This does not mean, however, that wear of other machine parts in service can be explained by this theory. In fact, the wear destruction of gear teeth by scoring in service seems to agree not with the Fink theory but with the weld theory of Tomlinson. Likewise, cases are known where an oxide film on rubbing parts is beneficial.

GENERAL MOTORS INVESTIGATES CAUSE OF BRINELLING

To determine the cause of, and to find a practical remedy for, brinelling of ball and roller bearings, particularly in freight-car and motor-truck shipments of automobiles, the research laboratories section of the General Motors Corporation conducted a series of investigations. In preparation for the study of ball- and roller-bearing indentation, all available examples of this form of damage were examined. Automobiles shipped to the Pacific Coast were found to have suffered more damage than those going shorter distances, and, also, this damage was more severe in winter than in summer. The manner in

[4] "The Influence of Oxide Films on the Wear of Steels," by S. J. Rosenberg and L. Jordan, Transactions of the American Society for Metals, vol. 23, 1935, pp. 577–613.

[5] "The Influence of Oxide Films on the Wear of Steels," by S. J. Rosenberg and L. Jordan, Transactions of the American Society for Metals, vol. 23, 1935, pp. 609 and 610.

[6] "Load-Carrying Capacity of Extreme-Pressure Lubricants," by S. A. McKee, T. A. Harrington, and T. R. McKee, S.A.E. Transactions, vol. 28, 1933, pp. 217–223.

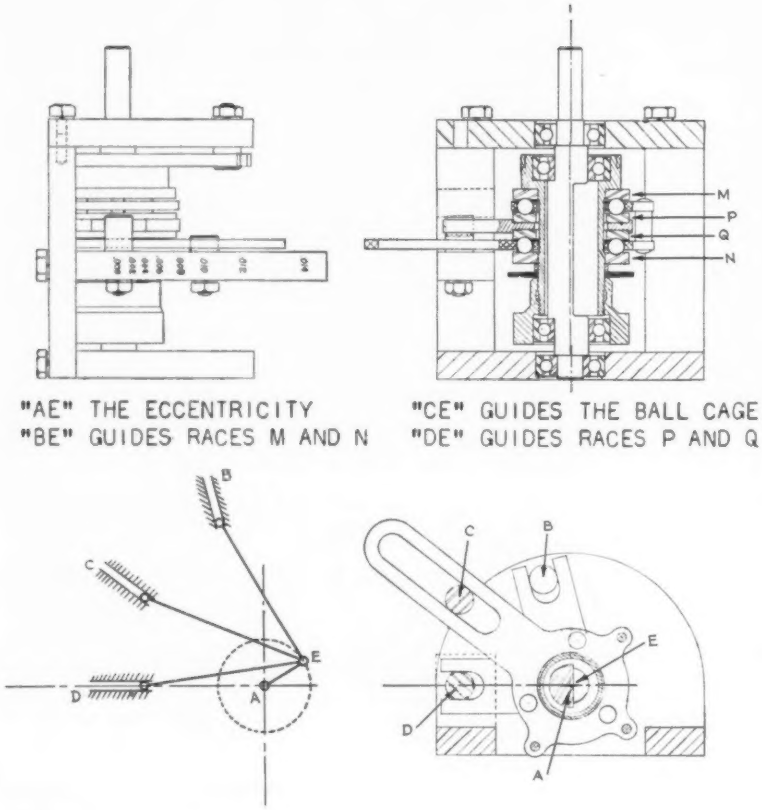

FIG. 7 VIBRATION WEAR-TEST MACHINE THAT WAS DEVELOPED BY THE RESEARCH LABORATORIES SECTION, GENERAL MOTORS CORPORATION

which the automobiles were loaded in the freight cars had a great influence on the damage that was done, as cars carrying the weight on the wheels were damaged more than cars that were blocked up.

With this background, a laboratory-test machine was designed to permit wide variation in load, speed of operation, amplitude of vibration, and temperature, with the hope that it could be made to produce damage of the type occurring in service. The test specimens used are commercial ball thrust bearings, the races of which are caused to rotate relatively to one another through a small angle while loaded by a calibrated spring. Fig. 7 shows the construction and principle of operation. A framework supports a central shaft on two ball bearings, and a tubular structure is carried by the shaft on a second pair of ball bearings, the axes of which are slightly eccentric to the axis of rotation of the shaft. Test specimens, two commercial ball thrust bearings, are carried by the tubular structure and are loaded by a pair of calibrated disk springs. The load can be varied by adjusting the nut on the threaded end of the tubular structure which bears against the calibrated disk springs. The tubular structure carries a slotted arm that engages the guide pin *B*. As the shaft is rotated, the tubular-member assembly will be carried around by eccentrically mounted bearings the same as the big end of an engine connecting rod is carried around by the crankshaft. The two outer test specimens, races *M* and *N*, are held to the tubular member by friction of the spring load. The two inner races *P* and *Q* are held to a central plate by the same spring load. This plate also carries a slotted arm that engages guide pin *D*. Special ball cages, accommodating three balls only for each of the two bearings, are riveted together so that both cages are guided by a common slotted arm, engaging guide pin *C*.

The positions of guide pins *B* and *C* can be varied, guide pin *D* being fixed. If the axes of guide pins *B*, *C*, and *D* all coincide, the entire specimen assembly will move like the big end of a connecting rod without relative motion of the specimen races or ball cages. When guide pins *B* and *C* are adjusted, as shown in the end-elevation drawing and the diagram, the races guided by pins *B* and *D* will move relatively to one another through a small angle. The balls will, of course, move through half this angle. However, to prevent the balls from creeping, which would destroy the uniformity of the contact patterns, the ball cage is guided by pin *C* which lies on a line bisecting the angle *BAD*. The distance *AC* must be increased as the angle *BAD* is increased if the balls are to have their natural motion.

As built, eccentricity *AE* is 0.040 in., and pins *B* and *D* are 2 in. from the axis *A*. Angle *BAD* can be varied from 0 to 120 deg, and, by a simple calculation, the relative oscillation of the two sets of races can be varied from 0 to 2 deg, the movement of the balls on the races being, of course, one half as great. The pitch diameter of the ball groove is 1.672 in., and movement of the balls on the races can be varied from 0 to 0.014 in. Spring load can be varied from 10 to 400 lb per ball, corresponding to unit pressures, as calculated by the Hertz equation, of 97,500 to 332,800 lb per sq in. The machine is driven by an adjustable-speed direct-current motor.

In operation, bearing indentations closely resembling those found in practice could be produced by this machine. The region of damage was found to be surrounded by rust just as occurs in practice. Indentations resulted at low as well as at high loads, requiring, however, a greater number of oscillations at the former to produce equal damage. Damage was independent of the speed of the operating motor but was roughly proportional to the total number of oscillations. It was less at large than at intermediate amplitudes. Appearance of damaged areas on the test specimen were somewhat rougher than those of ball and roller bearings taken from actual installations, probably due to the fact that, in use, these areas are generally smoothed by rotation of the bearing after indentations are formed.

Among the preliminary tests made with the machine were two series of runs designed to check service observations on the effects of load and amplitude of oscillation. Photographs of the contact areas for these tests at 38 magnification are reproduced in Fig. 8, the upper row showing the effect on the three balls of total loads of 100, 200, 400, and 600 lb each, when operated 25,000 cycles at oscillation amplitudes, of the balls to the races, of 0.006 in. and using as a lubricant sodium-soap grease to which 70 per cent of commercial winter extreme-pressure transmission lubricant had been added. Severity of the markings will be seen to increase with load. The lower group of four photographs, also at 38 magnifications, shows the effect of varying the amplitude of oscillation. These tests were run at a total load of 600 lb, 200 lb per ball for 100,000 cycles, using as a lubricant sodium-soap grease to which 70 per cent of commercial winter extreme-pressure transmission lubricant had been added. Amplitudes, reading from left to right, are 0.000, 0.004, 0.008, and 0.012 in. Damage to the race is seen to be greater at the intermediate amplitudes than at an amplitude of 0.012 in. This is in agreement with the automobile universal-

joint test and the service observations that were discussed earlier in this paper.

RELATION OF VISCOSITY TO RACE DAMAGE

A series of tests was run on a large variety of oils and greases. Some of these lubricants are listed in Table 1 in the order of their ability to reduce the severity of race damage. In each case, the machine was run at a total load of 600 lb and an amplitude 0.006 in. for 100,000 cycles. The only property of these lubricants that appeared to determine their rating was the viscosity at atmospheric pressure and operating temperature. Because of their superior performance in heavily loaded gears, extreme-pressure lubricants were thought to be more effective in reducing bearing damage than normal lubricants, but all these lubricants also ranked in the order of their viscosities. This also was true for saponifiable oils. Several oils were tested at freezing temperature and at 0 F, with the result that their rating fell in proportion to the viscosity change. This would seem to account for the increased damage occurring to automobile-wheel bearings in automobiles shipped in the winter.

TABLE 1 ABILITY OF LUBRICANTS TO REDUCE CORROSION INDENTATIONS

Rating	Identification symbol	Temperature, F	Lubricant
1	*K*	70	S.A.E. No. 10W asphalt-base engine oil and aluminum soap
2		70	DuPont GD-153 extreme-pressure base; straight
3		70	Oleic acid; straight
4		70	Lard oil
5		70	S.A.E. No. 20W asphalt-base engine oil and $1^1/_2$% of DuPont GD-162 extreme-pressure base
6		70	Castor oil
7	*G*	70	S.A.E. No. 20W asphalt-base engine oil
8		70	Raw linseed oil
9		70	No. $2^1/_2$ cup grease and 1% of oleic acid
10		70	Experimental castor-oil grease and 5% of DuPont GD-153 base
11		70	SSG 06 steering-gear grease
12	*F*	70	Experimental lard-oil grease containing no mineral oil
13		70	Experimental castor-oil grease containing no mineral oil
14		70	Commercial wheel-bearing grease and 5% of pine oil
15	*E*	70	Sodium-soap grease and 70% of commercial winter extreme-pressure transmission lubricant
16		70	Sodium-soap grease, and 70% of commercial winter extreme-pressure transmission lubricant and oleic acid
17		70	Commercial extreme-pressure wheel-bearing grease
18		70	Experimental grease with 4.7% of zinc oxide and 5% of lead soap
19		70	Glycerine
20		70	Crisco, cooking fat
21	*D*	70	Commercial grease containing zinc oxide
22		70	Black lubricating oil of 90 viscosity at 210 F
23	*C*	70	Commercial sodium-soap chassis lubricant
24		0	S.A.E. No. 20W asphalt-base engine oil
25		30	Experimental lard-oil grease containing no mineral oil
26		70	S.A.E. No. 20W mid-continent engine oil
27	*B*	70	Commercial slushing oil
28		70	Painters and varnish makers naphtha; immersed
29		70	Water; immersed
30		32	No. $2^1/_2$ cup grease and 1% of oleic acid
31		30	Sodium-soap grease and 70% of commercial winter extreme-pressure transmission lubricant
32		29	Sulphur saponifiable extreme-pressure base
33		0	Experimental lard-oil grease containing no mineral oil
34		0	Sodium-soap grease and 70% of commercial winter extreme-pressure transmission lubricant
35		70	Sodium-soap grease and 30% of DuPont GD-162
36		0	Experimental castor-oil grease containing no mineral oil
37		70	Sodium-soap grease and 50% of sulphur base
38	*A*	70	Sodium-soap grease
39		70	Sodium-soap grease, 45% of sulphur base, and 10% of lead soap
40		70	Dry
[a]	*H*	70	S.A.E. No. 90 commercial winter extreme-pressure transmission lubricant

[a] This lubricant was not used in the comparison but was used on one of the specimens shown in Fig. 9.

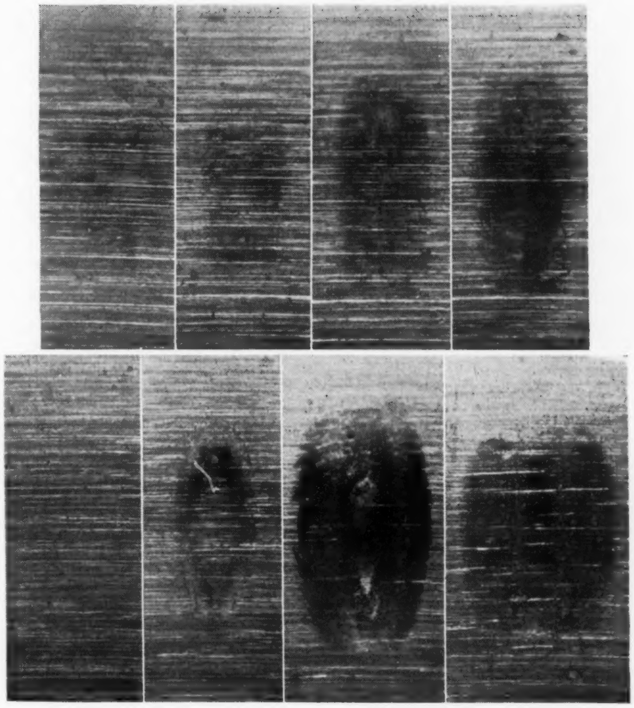

FIG. 8 EFFECT OF VARYING LOADS AND AMPLITUDES OF OSCILLATION

(In the views shown in the upper row, the amplitude was kept constant at 0.006 in., and the load was 100, 200, 400, and 600 lb, reading from left to right. In the views shown in the lower row, the load was kept constant at 60C lb, and the amplitude of oscillation, reading from left to right, was 0.000, 0.004, 0.008, and 0.012 in., respectively. The constant-amplitude tests were run for 25,000 cycles, and the constant-load tests, for 100,000 cycles. The lubricant for each series of tests was sodium-soap grease to which 70 per cent of commercial winter extreme-pressure transmission lubricant had been added.)

Fig. 9 shows the test specimens for several of the lubricants listed in Table 1. These are arranged in opposite order to the table; that is, reading from left to right, the illustrations show the effect of decreasing viscosity. The worst of these lubricants, from the standpoint of test-specimen damage, is the type of grease commonly used for automobile-wheel bearings. The reason for this interesting fact is that the viscosity must be high enough to prevent leakage. A preloaded pinion bearing, filled at the factory with sodium-soap grease gave considerable trouble by brinelling during shipment to the West Coast. This trouble was greatly reduced when 70 per cent of commercial winter extreme-pressure transmission lubricant was added.

These tests and other observations indicated that, wherever

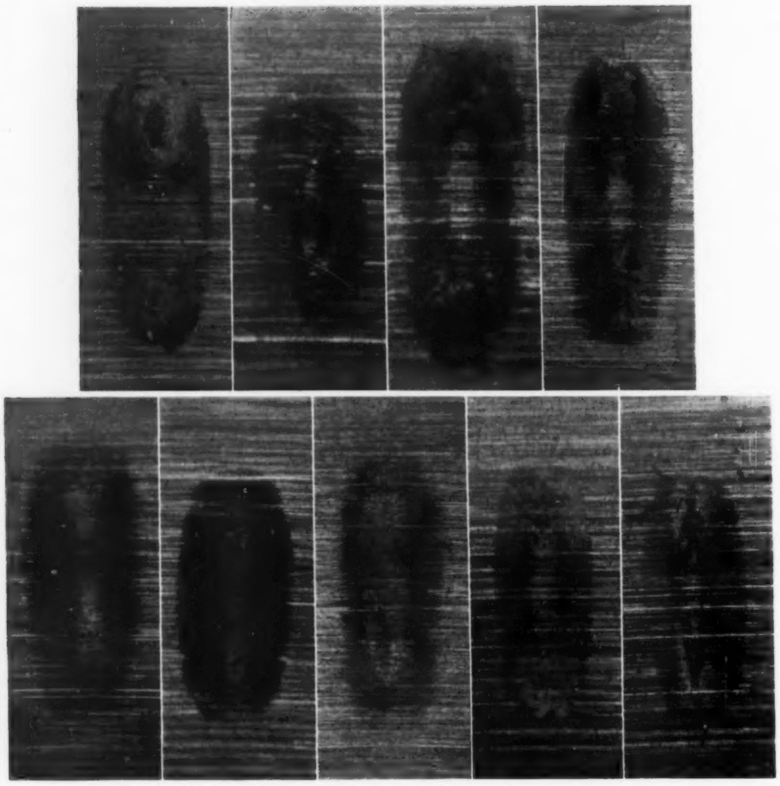

FIG. 9 EFFECT OF VARYING THE LUBRICANT

(In these tests, which were run for 100,000 cycles in each case, the lubricants used for the bearings shown in the top row, reading from left to right, were sodium-soap grease, commercial slushing oil, commercial sodium-soap chassis-lubricating grease, and commercial grease containing zinc oxide. The lubricants for the bearings in the bottom row, from left to right in the order named, were sodium-soap grease to which 70 per cent of commercial winter extreme-pressure transmission lubricant had been added, experimental lard-oil grease containing no mineral oil, S.A.E. No. 20W asphalt-base engine oil, S.A.E. No. 90 commercial winter extreme-pressure transmission lubricant, and S.A.E No. 10 asphalt-base engine oil to which aluminum soap had been added. The amplitude of oscillation and the load were held constant at 0.006 in. and 600 lb, respectively, throughout.)

possible, low-viscosity lubricants should be used in bearings subject to indentation. Following Fink's theory of oxidation wear, when heavy greases are used in such bearings, the grease apparently is pushed aside by the balls or rollers, and air is admitted to the area of contact with resulting rapid oxidation. Lighter lubricants are held to the balls and races and provide the contact area with a certain degree of protection against air and, hence, reduced oxidation. At low temperatures, oils and greases that are sufficiently fluid to provide protection for the bearings at room temperature may become too viscous to adhere to the balls or rollers. A lubricant for this purpose should, therefore, be one that adheres strongly to the balls or rollers and the races under all conditions of service and under the highest and lowest temperature that will be encountered. It should not drain off during long periods of storage but should be present in sufficient quantity so that the bearing can be run, as when the automobile is being loaded on the car, and still insure coverage for the contact region.

An attempt was made to meet these requirements by using an S.A.E. No. 10 engine oil with sufficient aluminum soap to give a viscosity approximately equal to S.A.E. No. 30 oil (lubricant *K*, Table 1), the rubbery consistency of this lubricant being relied upon to provide a cover and resist draining. A service test was arranged in which 25 preloaded pinion bearings were filled and assembled in axles. The axle assemblies were set aside in a position to drain at room temperature for two weeks, after which they were assembled in cars and shipped to the Pacific Coast in the late winter months. Inspection reported two bearings of the lot to be slightly noisy. Although not entirely satisfactory, this experiment seems to justify the theory on which it was based and, perhaps, indicate the characteristics that a better lubricant should have.

PROTECTION AGAINST AIR BY PLATING OR SUBMERGENCE

As a further test of the oxidation-wear theory, a number of laboratory tests were run in which protection against air was attempted by other means than oils or greases. The photographs reproduced in Fig. 10 show the damaged areas after 100,000 cycles under a 600-lb total load and 0.006-in. amplitude for various bearing-surface

FIG. 10 EFFECT OF VARIOUS SURFACE COVERINGS

(The bearings in the upper row were of steel and were run dry, with water lubrication, and submerged in mercury; in the lower row, the balls and the races were covered with platings of tin and copper and amalgams of tin and copper, the order being from left to right in each row. These tests were run under the same conditions as Fig. 9; 100,000 cycles, 0.006 in. amplitude of oscillation, and a total load of 600 lb.)

conditions. Reading from left to right in the upper row, these were dry, lubricated with water, and submerged in mercury. In the lower row, the conditions were, again reading from left to right, tin-plated balls and races, copperplated balls and races, balls and races coated with a tin amalgam, and balls and races coated with a copper amalgam. In all cases where the races were plated, the plating was removed before photographing.

The dry and water-lubricated specimens are shown for purposes of comparison. That tin and copper-plate do not protect the steel race is evident since the damage is similar to the unlubricated race. Increased damage for the specimen submerged in mercury may be due to the fact that air was trapped at the contact areas and, since this air was under increased pressure, it was possibly more active. The plated and submerged tests were intended to determine separately the effect of plated surfaces and the effect of mercury so as to isolate the effect of amalgam coating. With tin and copperplated races excluding air by adding mercury to amalgamate with the plating on the specimen and so penetrate into the smallest spaces was thought to be possible. The tin-plated specimen was wetted with mercury, the amalgam being formed by hand rubbing before the test was run. On the copperplated specimen, the amalgam was formed by running under load as an ordinary ball bearing, while submerged in mercury. The specimen was then assembled in the test machine and submerged in mercury for the test. The undamaged condition of the two amalgamated specimens may be due to superior effectiveness of the amalgams as lubricants or, as would seem more probable, it may be the direct result of exclusion of air. In view of the greater damage-resisting effectiveness of normal low-visocisty lubricants compared with normal high-viscosity lubricants, as shown in Table 1 and Fig. 9, the latter interpretation appeared to be justified.

However, a more direct test of Fink's theory seemed desirable. Rather than attempt the difficult technique of producing an oxygen-free atmosphere of nitrogen, the test was run in vacuum. The test machine and a $^1/_{30}$-hp alternating-current driving motor were placed in an ordinary 10-in. bell jar which was then pumped down to 0.00000002 atm. Before installation in the bell jar, the motor was disassembled and carefully dried of oil. The test machine was completely disassembled and all parts were successively washed in gasoline, benzol, dilute phosphoric acid, and, finally, in alcohol.

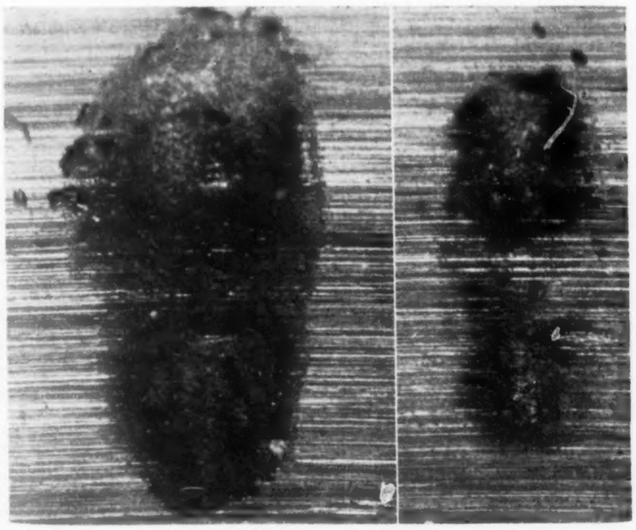

FIG. 11 EFFECT OF AN OXYGEN-FREE ATMOSPHERE

(The view at the left shows the appearance of a test specimen, 38 magnification, after being subjected to a total load of 600 lb and an amplitude of oscillation of 0.006 in. for 100,000 cycles in air. The other view is of a similar specimen that was tested in a vacuum, pressure of 29.4 × 10^{-8} lb per sq in., all other conditions being the same. In both tests, the bearing had no lubrication.)

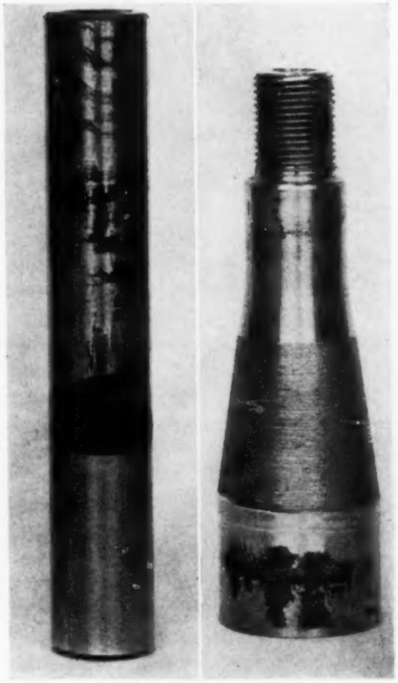

FIG. 12 EXAMPLES OF CORROSION IN OTHER AUTOMOBILE PARTS

(Left, a hardened automobile kingpin that corroded where it was attached to the axle; right, an automobile front-wheel spindle that shows damage where pressed-on inner race of roller bearing had rested.)

The test was run dry for 100,000 cycles at 600-lb total load and 0.006-in. amplitude. A photograph of the test specimen at 38 magnifications is shown in Fig. 11 at the right. For direct comparison, the view at the left shows the same specimen run dry in air, other conditions being unchanged. This test shows that damage to the test specimen can occur in a highly rarefied atmosphere, although the damage is greatly reduced as compared with tests run in air. That the adsorbed-oxygen film on the test specimen was reduced in vacuum is not likely. Comparing the amalgam tests, Fig. 10, and the vacuum test, Fig. 11, the assumption must be made either that the amalgam offered better protection against air and the adsorbed-oxygen film on the test specimen than was given in vacuum or amalgam is indeed a superior lubricant. On either assumption, discarding the oxidation-wear theory is still not necessary. The total test load of 600 lb corresponds to approximately 265,000 lb per sq in. for each ball, and the damage in vacuum may be purely mechanical removal of metallic particles under this severe load. In air, the damage may be the combined effect of oxidation wear and mechanical removal of particles. On this interpretation, normal lubricants provide a degree of lubrication as well as partial protection against air.

The nature of the damage produced in the test-machine specimen is clearly shown in Fig. 13. The damaged area shown in the top photograph was produced by operating for 500,000 cycles under 1200-lb load and 0.007-in. amplitude. The other three following photographs show sections at 500 magnification through the specimen; section *A-A* is through an undamaged portion of the specimen which shows the original contour; sections *B-B* and *C-C* are taken through a portion of the damaged area, showing that particles of appreciable size were removed during the test.

CORROSION OF TIGHTLY ATTACHED MACHINE PARTS

Severe corrosion frequently is found on machine parts that are attached to one another in a manner designed to prevent relative movement, such as keyed taper shafts and hubs, press-fitted wheels and axles, and the like. Where such corrosion

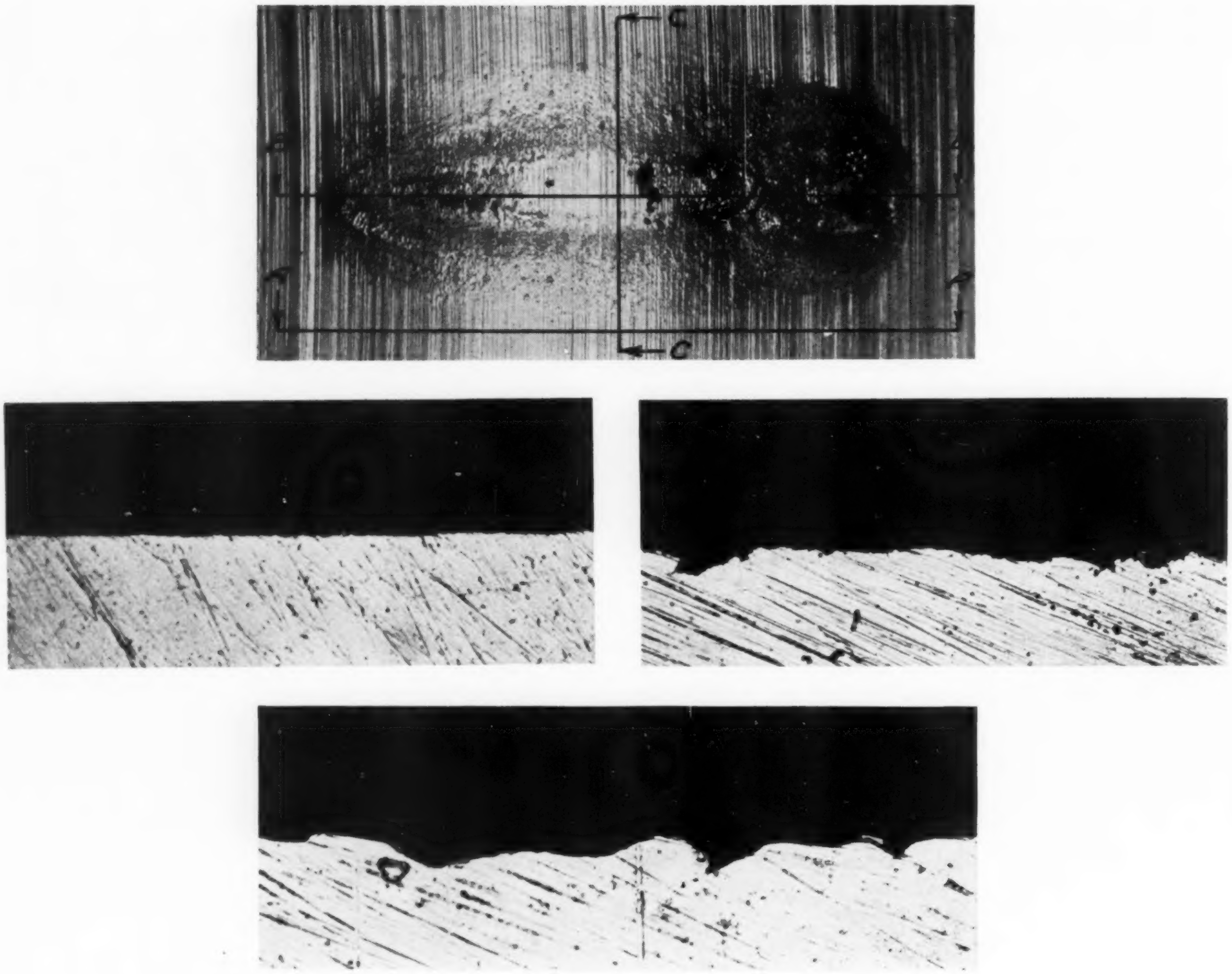

FIG. 13 NATURE OF DAMAGE PRODUCED BY WEAR-TEST MACHINE

(The top view, 35 magnifications, shows the damage produced by 500,000 cycles of operation with a 1200-lb load and an oscillation amplitude of 0.007 in. when S.A.E. No. 20 asphalt-base engine oil was used as a lubricant. The view at the left center, 500 magnifications, is a section along the line *A-A* of the top view, which lies in the undamaged portion, and shows the original contour of the test specimen. The views at the right center and bottom, both 500 magnifications, are sections along the lines *B-B* and *C-C*, respectively, of the top view and show that particles of appreciable size were removed in the test.)

occurs, the attached members will be found to be subjected to fluctuating loads as from vibrations or from rotating loads. Two examples of this corrosion are shown in Fig. 12. One of these is a hardened automobile kingpin that corroded where it was attached to the axle. The second is an automobile front-wheel spindle showing a damaged region where the pressed-on inner race of a roller bearing had rested. In such cases, the corrosion is probably produced in the same manner in which indentations are produced in ball and roller bearings. The slight movement that seems to be necessary for oxidation is present due to load variations and deformation under stress. These cases are mentioned to call attention to the fact that oxidation wear is not peculiar to ball and roller bearings but occurs on steel parts whenever high load and low slip are present.

This paper has discussed the effect of lubricants on oxidation wear of ball and roller bearings with particular reference to the damage that occurs during shipments of automobiles. The remedies that are applied in practice are various, depending upon cost. Where damage occurs on a large percentage of shipments, the cheapest solution is to support the automobiles on their axles instead of their wheels. Where this damage is of infrequent occurrence, the cheapest solution is the replacement of the damaged parts. However, a wide field still remains for development of lubricants that will better resist oxidation wear.

CONCLUSIONS

So-called brinelling of ball and roller bearings is not brinelling. The indentations that are observed result from a form of wear which is dependent on or aggravated by the presence of oxygen. This situation cannot become serious if air is excluded from the region of contact between the races and the balls or rollers. Oxidation wear can be greatly reduced but cannot be eliminated by the use of low-viscosity lubricants. Use of these lubricants for many installations of ball and roller bearings is impractical due to inadequate oil seals.

No general commercial solution is now in use. The remedy that is applied varies according to circumstances.

The author gratefully acknowledges the valuable assistance given by W. D. Gove and D. B. Elfes and the cooperation of the New Departure Manufacturing Co., the Timken Roller Bearing Co., and the Pratt and Whitney Aircraft Co.

Stress-Optically Less Sensitive

MATERIALS *in* PHOTOELASTICITY

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IN THE optical determination of principal stresses by polarized light and models made of transparent materials, two distinct and independent operations are to be performed; (*a*) measurement of the intensity of the stress at a given point and (*b*) the determination of its orientation with respect to a system of coordinate axes. The intensity of the stress at any point is evaluated from a fringe photograph in black and white, called monochromatics, obtained by using circularly polarized monochromatic light. The axis of each fringe in such a pattern, as in Fig. 1, represents the locus of points at which the difference of the principal stresses is constant and, in numerical value, proportional to the order of the fringe containing the point in the stressed model.

The direction of the stress is obtained with plane polarized white light. When projected on a screen, the stress fringes now appear in multicolor, called isochromatics, because of the nature of the light used, but one or more black bands, called isoclinics, also are projected, as in Fig. 2. For a given orientation of the plane of polarization of the incident light, the axis of each isoclinic represents the locus of points at which the principal stresses are respectively parallel and perpendicular to the direction of the plane of the incident light.

The isochromatic fringes and the isoclinic bands can be easily distinguished, however, for, in addition to the fact that the isochromatics are in color and the isoclinics in black and white, the latter bands are variable in position, with the change in the plane of polarization of the incident light, while the isochromatics are fixed, being invariant to this change.

OPTICAL CONSTANTS OF MATERIALS

In early photoelastic investigations when the intensity of stress was evaluated by a compensation method, such as color matching, quartz wedges, Coker's tension bar, and similar means, a model made of glass, with low optical sensitivity to an applied stress, was used for obtaining both isochromatics and isoclinics. Due to difficulty in machining glass into models of intricate design having holes, notches, or similar discontinuities of boundary, this material was later replaced by xylonite (celluloid) a synthetic plastic about four times optically more sensitive to stress than glass. In recent years, as a result of the development of the fringe-photograph method of evaluating the intensity of stress, materials having higher stress-optical sensitivity, such as bakelite, phenolite, marblette, and similar substances, are being used instead of glass or celluloid. The fringe-stress equivalents per inch of thickness, of the various photoelastic materials as tested by the author, and also their relative stress-optical sensitivities, with glass as unity, are given in Table 1. As the mechanical and optical properties of the synthetic plastics greatly vary with the manufacturing conditions, these values should be regarded as approximate.

A graphical picture of the relative stress-optical sensitivity of two materials, such as plexiglas and marblette, is illustrated by the fringe patterns of Fig. 1. When using these materials of higher stress-optical sensitivity, many investigators make a practice of obtaining both the isoclinics and monochromatics from a single model, which is practical only, within certain limits of accuracy, when the model is of simple type and when a lower load is applied to the model for the determination of the isoclinics than that used for the determination of the monochromatics.

TABLE 1 OPTICAL CONSTANTS

Material	Fringe-stress value, lb per sq in. per in.	Relative optical sensitivity
Glass	1150	1.00
Plexiglas and lucite (pontalite)	920	1.25
Celluloid	295	3.90
Tenite	255	4.50
Pollopas (Germany)	180	6.40
Vinylite	90	12.80
l'Orca (France)	80	14.40
Bakelite	70	16.50
Phenolite (Japan)	55	21.00
Catalin	35	32.80
Marblette	23	50.00
Fiberlon	20	57.50

MATERIAL WITH LOW STRESS-OPTICAL SENSITIVITY NECESSARY

In problems of intricate design, two separate models of exactly similar dimensions but made of two different materials can, however, be used with advantage. Thus, for measurement of the intensity of the stress by monochromatics, a material of higher stress-optical sensitivity, with high elastic constants, is desirable, so that under a moderate applied load, a rich fringe pattern of stresses will be available. Bakelite has been the most favored photoelastic material for this purpose. Recently, however, the use of marblette, as manufactured or heat-treated for higher strength, has been advocated by the author[1] as better meeting certain specific needs.

On the other hand, if we desire to find the direction of the stress from isoclinics, then a material of low stress-optical sensitivity should be used for the model, so that under the same intensity of applied load as in the previous test, the projected image of the stressed model will contain the fewest possible number of isochromatics. This is the condition that leads to the clearer identification and accurate tracing of the isoclinics. Glass and celluloid have been used for this purpose in the past. The author recommends a new synthetic material, plexiglas, which has a stress-optical sensitivity approximating that of glass, for the following reasons which also apply to lucite (pontalite), another plastic having approximately the same optical and mechanical properties as plexiglas.

The importance of using a material with low stress-optical sensitivity for the isoclinics is evident from the following considerations:

(1) When a permanent record of the isoclinics is made by using photographic methods and making a photographic print of the projected image of the stressed model, both the colored isochromatics and the black isoclinics will appear in black and white, as in Fig. 2, which shows the pattern of isoclinics and

[1] "A New Photoelastic Material," by A. G. Solakian, MECHANICAL ENGINEERING, vol. 57, 1935, pp. 767–772.

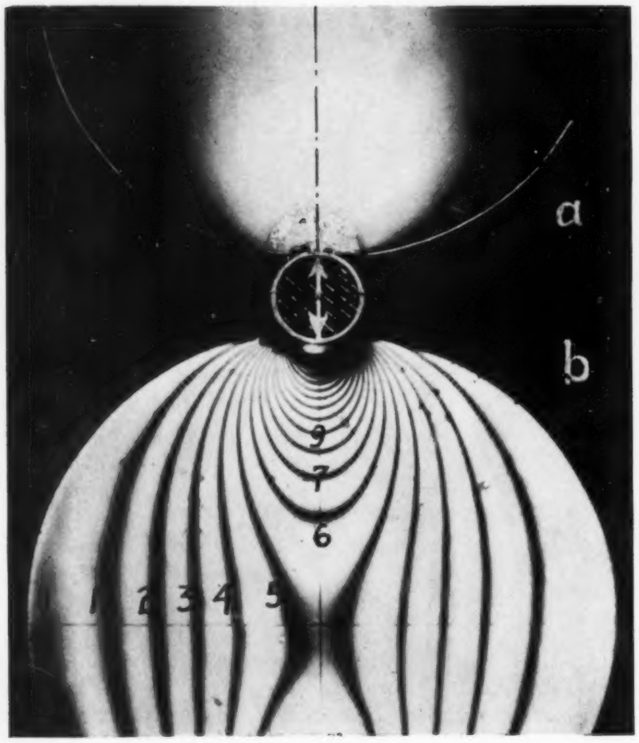

FIG. 1 MONOCHROMATIC FRINGE PATTERN OF STRESSES IN CIRCULAR DISKS OF TWO PHOTOELASTIC MATERIALS HAVING DIFFERENT STRESS-OPTICAL SENSITIVITIES. (*a*) PLEXIGLAS; (*b*) MARBLETTE

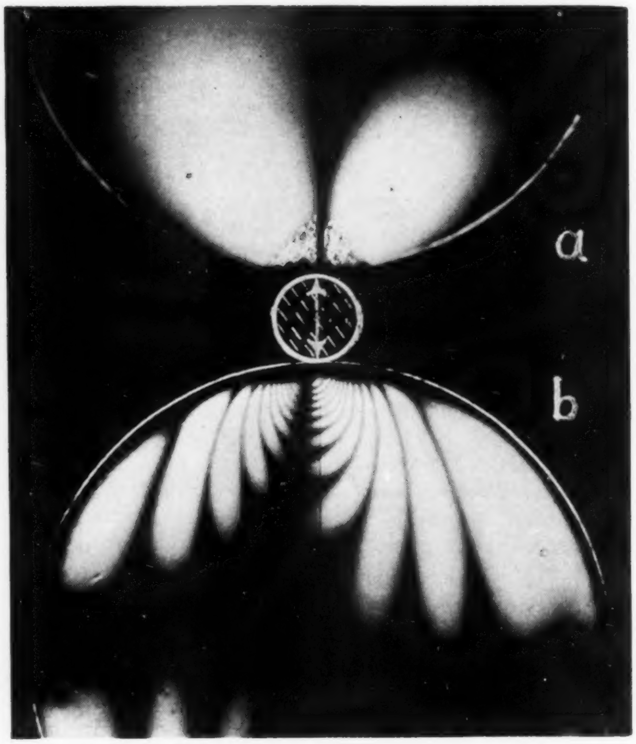

FIG. 2 5-DEG ISOCLINICS, WITH ISOCHROMATICS AS IN FIG. 1 BUT SMALLER LOAD, FOR DISKS HAVING DIFFERENT STRESS-OPTICAL SENSITIVITIES. (*a*) PLEXIGLAS; (*b*) MARBLETTE

isochromatics of two disks made of plexiglas and marblette, under similar testing conditions. As a result, the identification of an isoclinic, even in a model of simple type, will be exceedingly difficult, and becomes practically impossible where an isoclinic overlaps an isochromatic or is at a small angle to it.

(2) In the case of a model with a few holes or similar cuts, the projected image of the stressed field will be a very complicated pattern of numerous small and large isochromatics and isoclinics. With this condition, the identification of isoclinics and the accurate tracing of their middle axes will be difficult, for various orientations, from 0 to 90 deg, of the plane of the incident light. Any error in the true position of the isoclinics will affect the accuracy of the resulting stress trajectories, as well as the computed values of the principal stresses or their components.

(3) Another point of importance is the fact that models made of materials with high stress-optical sensitivity usually are not entirely free from the effect of initial strain. Consequently, they will show the existence of initial isoclinics before a load is applied to the model. This phenomenon, although useful in determining the existence of such exceedingly small initial strain in the model, which is not large enough to appear in colors, will ultimately alter the true path of the true isoclinics resulting from an applied load. This effect may not be serious in regions where the intensity of the applied stress is large in comparison with that of the initial stress. However, in many other sections of the model, farther from the point of the applied load, the effect of the initial stress may alter or govern entirely the paths of the true isoclinics, thus introducing serious errors in the final results.

(4) Materials of higher stress-optical sensitivity show the effect of aging, introducing internal strain at the free edges of the plate, more predominantly and hence relatively in shorter time than those of lower sensitivity. This, in turn, will have its effect on the initial isoclinics or may change the path of the true isoclinics.

ADVANTAGES OF PLEXIGLAS AND LUCITE FOR PHOTOELASTIC WORK

From these considerations, photoelastic investigators use or recommend either glass or celluloid for the isoclinics. Glass would be the ideal material, were it not for the difficulty of machining it into intricate models and its fragility under moderate stresses. Celluloid, in the absence of a more suitable plastic of low stress-optical sensitivity, naturally has been the next choice of the investigators. However, a comparison of several photoelastic characteristics, as regards the isoclinics, of this material, and of plexiglass and lucite (pontalite), indicates that plexiglas and lucite possess certain advantages for this purpose, which are:

(1) As evident from Table 1, the optical sensitivity of plexiglas and lucite (pontalite) is only 1.25 times greater than that of glass, while that of celluloid is 3.90 times greater

(2) Plexiglas and lucite (pontalite), unlike celluloid, are of water-clear transparency practically equal to that of glass

(3) Like celluloid, they can readily be subjected to any machining operations

(4) They have less creep effect, as compared with celluloid, under similar conditions of applied stress and time intervals

(5) Elastic constants are higher than those of celluloid. Plexiglas and lucite (pontalite) have an elastic limit of 4000 lb per sq in., which is the same as celluloid; modulus of elasticity of 400,000 lb per sq in., that of celluloid is 350,000 lb per sq in.; and a maximum strength of 10,000 lb per sq in. as compared with 7500 lb per sq in. for celluloid.

With such advantages, the use of plexiglas and lucite (pontalite) as photoelastic materials for determining the direction of principal stresses through isoclinics, increases the accuracy of photoelastic technique and brings it nearer perfection.

Engineering Value of Adequate OPERATING INSTRUCTIONS

By D. L. ROYER

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MODERN industry employs many diversified machines and kinds of apparatus. This equipment is being constantly replaced as it wears out, breaks down, or becomes obsolete through the introduction of improved equipment and methods. The old is constantly giving way to the new and improved. Although principles of construction and operation frequently remain the same, the trend is definitely away from equipment requiring any great manual effort or skill on the part of the operator. The personal skill and physical endurance that once were required of the workman are being replaced by the precision and tireless endurance possessed by the machine.

But the machines and apparatus, upon which have been imposed the great industrial burdens of modern times, sometimes fail, resulting in loss of time, spoilage of materials, damage to property, costly replacements, and frequently painful or fatal injuries to workmen. Efficiency requires that these failures be avoided. The meeting of this demand is probably the greatest problem encountered in industry.

Men should be able to control the machines and apparatus used in industry because they design, build, and operate them, but the designers and builders sometimes forget the operators and operating problems. Too frequently, the products of their ingenuity and skill are turned over to the operator with only a slight appreciation of the problems that will be encountered in service and without any definite operating instructions. The trend is to make the machine foolproof, and to make it automatic in operation and so rugged in design that it can resist faulty operation and abuse without failure. Someone, however, must assume responsibility for repairs, adjustment, and maintenance after the equipment is put into service.

OWNER RESPONSIBLE FOR DEVELOPING OPERATING INSTRUCTIONS

Developing adequate operating instructions appears to be the responsibility of the owner of the equipment or his supervisor in charge of operation. Designers and builders of equipment usually are anxious, however, to share the responsibility of developing effective operating instructions because competition forces them to see that operation after sale is satisfactory. The final responsibility, however, for developing such instructions and their enforcement is clearly the responsibility of the persons in charge of the operation of the equipment.

Adequate operating instructions clearly require the cooperation of both designer and builder with the operator for their development. For example, the determination of safe capacities and loads may be ignored by the operator in an endeavor to obtain maximum production with minimum investment. When failures occur because of overloads, the designer or builder frequently points out that the equipment was not intended or sold to operate at the capacities responsible for the failure. Too frequently, however, the designer and builder have only a vague idea of the behavior of their products through the years of operation. The "swivel-chair instruction writer," who does not familiarize himself with the problems of the operator, is headed for difficulties that result in failures and inefficiency. Many instruction writers are too far removed from the problems of operation to appreciate their ramifications and to produce instructions that will completely cover the various phases of the probelm. Further, individual plant conditions will frequently require some deviation from the theoretical formulas evolved by the designer and builder.

Some students of the problem have the opinion that to give operators and workmen detailed instructions covering each phase of their duties limits personal ingenuity and incentive, because these individuals will follow them but go no farther. While this criticism appears to be justified in certain activities, whether it can be fairly applied to the problem of operating practice is doubtful. Many employees will not go beyond their instructions, even to the extent of not pointing out opportunities for improvements of any kind, but these same employees are usually the type that take refuge in the statement "no one told me" when they are wholly or partly responsible for a failure involving circumstances for which they had no instructions. When the problem of developing adequate operating instructions is given the attention that it deserves, every individual interested in the operation and efficiency of the equipment is given an opportunity to develop his personal ingenuity and ability.

When an organization commences developing adequate operating instructions a number of interesting conditions usually arise. Frequently, nobody knows the correct operating procedure under certain circumstances. The owner of the equipment or his supervisors may have ideas that are influenced by the necessity of attaining maximum production. The operator, with his familiarity of the equipment's behavior gained by practical experience, may not agree because of his knowledge of the limitations in operation. The clever producer of adequate operating instructions will collect the ideas of the various interested individuals and, by collating and codifying, develop instructions that will guarantee efficient operation. When this course is followed, all concerned become more familiar with the problems involved and have a clearer understanding of the results desired and a singleness of purpose that produces these results.

Improvement in design and construction frequently follows when the designer and builder are brought in for consultation, because they get an appreciation of operating limitations and difficulties which could not be gained at long range.

PRINCIPAL REQUIREMENTS OF OPERATING INSTRUCTIONS

To be effective, adequate operating instructions must be correct, completely cover the subject, and they must be easily understood.

Correct instructions are not impossible or particularly difficult to produce but require thought and investigation. Many

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cases of industrial inefficiency continue indefinitely because incorrect instructions are issued and permitted to remain in effect. Some debate and controversy regarding the correctness of operating instructions may arise among those interested in the problem, but when these differences of opinion have been eliminated by carefully considering all phases of the problem and when the instructions have been revised to meet varying operating conditions, no doubt should exist about the complete accuracy and correctness of the instructions given to the individual workmen and operators.

Contradictory operating instructions are never desirable or correct. When formulating operating instructions, the first step should be the elimination of contradictions by clearly visualizing the operating problem. After it has been presented to the persons interested, their ideas and requirements should be brought into agreement.

The second requirement, that operating instructions be complete, presents a problem of some difficulty. Personal limitations of average operators of machines and apparatus must be considered. Giving the operator instructions beyond the point where the foreman or maintenance man should be called may be unwise, but their instructions should begin at the point where those to the operator leave off and should completely cover the more complicated operating problems that will be referred to them, from time to time by the individual operators and workmen.

To be certain that operating practice is clearly understood, instructions should be positive rather than negative. A "don't" precaution may be necessary but should always be accompanied by a "do" instruction. The workman must be told what to do if results are to be produced; if he is told what not to do, he can follow such instructions by doing exactly nothing.

Written instructions should be brief, concise, and definite sentences. Diagrams or illustrations which are frequently available from manufacturers of equipment, greatly assist in making instructions easily understood. Being definite in operating instructions cannot be too greatly stressed. Ambiguity, voluminous wording, and similar faults put the reponsibility for failures on the shoulders of the author.

INSTRUCTIONS SHOULD BE A MATTER OF RECORD

Definitely defining the form in which instructions should be given to the operator is impossible, because of the multiplicity of equipment to be covered and the many differing types of workmen and operators that must be instructed. Instructions should be a matter of definite written record, even though giving instructions to the individual workman verbally may be found desirable. Failure to record instructions always presents the possibility that important points may be forgotten, insufficiently stressed, or even ignored. Depending on the operation and number of persons involved, issuing instructions as mimeographed memoranda or printed booklets may be desirable. Instruction books provided by the manufacturers of the machines and equipment, supplemented by memoranda covering instructions to meet individual-plant operating conditions, may constitute the best answer to the problem. Whenever possible, booklets should be of pocket size and printed in legible type on durable paper.

When instructions are developed, given to the individual workmen responsible for operation, and enforced, a long step has been taken toward eliminating emergency operating conditions. However, the possibility of emergency conditions developing with certain equipment and the need for definite instructions to meet them must be considered. When instructions for unusual or emergency conditions are developed, they should not only be given to all workmen interested, but they should also be posted, preferably under glass, in locations where they will be readily available for reference should an emergency arise.

Development of adequate operating instructions is an important step toward efficient operation, but they accomplish no constructive purpose unless clearly understood by those for whom they are intended. The responsibility for this belongs to the foremen or other supervisors responsible for the operation. Merely stating the instructions or handing machine operators or workmen an instruction memorandum or booklet is rarely sufficient. The operation should be demonstrated several times by the supervisor, after which the operator should be asked to go through the routine or state the various steps. Only by this means can the supervisor be sure that the instructions are understood.

Observation of the aptitude of individual employees for absorbing and carrying out instructions may be one of the surest means for selecting individuals who have ability above the average for advancement.

If many workmen have difficulty in understanding and carrying out a set of instructions, they apparently require revision. However, if this is true of only a few workmen or operators, the fitness of these individuals for their particular jobs may be justly questioned.

THE ENFORCEMENT OF INSTRUCTIONS

Instructions must not only be understood but must be strictly enforced if results are to be produced. While the instruction of employees and the enforcement of instructions open up rather broad questions of executive control and employee selection, both are of equal importance with the problem of the formulation of adequate instructions. If the instructions for a given operation cannot be enforced with the average workman or operator, they probably require revision. But, before this is attempted, the reasonableness of the instructions should be considered. For example, expecting water tenders to blow down boilers each shift would not be unreasonable. However, a group of water tenders who had operated boilers without blowing down for a period of years were not under proper supervision when they failed to blow down as instructed, and failure to enforce this instruction caused serious difficulty in one instance where blowdown was necessary because of a change in boiler feedwater treatment.

When a set of operating instructions have produced satisfactory results and are followed without difficulty by all employees with the exception of a few, the reasonable conclusion is that those few are incapable of following or perhaps refuse to accept the instructions. Obviously, such employees should be replaced or transferred. To fail to enforce instructions not only makes for inefficiency and accidents but destroys the morale of the entire organization.

VISCOSITY, surface tension, and acidity of commercial internal-engine-lubricating oils are not affected by the copper, lead, and tin, with which they come in contact, according to a recent series of investigations dealing with the effect of these metals upon lubricant deterioration and the corrosive action of the lubricant upon them. Sludge formation is strongly stimulated by the presence of copper, while lead and tin have the opposite effect. Copper was badly corroded by the lubricant, but the film of reaction products protects lead and tin. Oil stored in open cans for a number of months before the tests were made was found to be more corrosive than the same lubricant taken from a sealed container.—*The Engineer*, Apr. 16, 1937, p. 449.

Economics of

MANUFACTURING LAYOUT

By A. F. MURRAY

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MANUFACTURING layout in its broader aspects involves product design, process development, tools and machinery, building construction, operation analysis and sequence, production control, material handling, storage and supply, product distribution, industrial relations, and similar topics. It is an economic problem of the first order, and a successful solution depends on the coordination of ideas and information from many sources involving practically the entire organization. "Making a layout" may be something much more than a matter of machine cutouts, map tacks, floor-plan boards, and pieces of string.

FIVE STEPS IN SOLVING A LAYOUT PROBLEM

Any project must be analyzed under the major headings of (*a*) nature of product, (*b*) purpose of layout, (*c*) geography of site, (*d*) time available for study and installation, and (*e*) quantity to be made. This information is necessary to answer "How much will it cost?" and "How much will it save?"

The nature of the product, its varieties, size, complexity, the finish and accuracy specifications, and the state of the art in design and process development will influence building construction, decision for standardized or special equipment, and extent to which outside suppliers are relied upon.

Increased production of familiar product enables us to proceed more easily and surely than with new items. Where cost reduction is the major factor, careful analysis of available equipment, detailed cost studies, and a review of design possibilities are required. Concentration results from changing market demands and the necessity for retaining older models in limited production.

Consolidation of several products of a similar nature, some with increasing and some with decreasing demand, may be beneficial to both conditions. Recent consolidation of street-railway motor machining with other motors of similar weight and size at East Pittsburgh developed new applications of draw-cut shapers and horizontal boring mills to power motor machining.

Relocation, particularly from one operating staff or plant to another, may provide the receiving group with a new product. Careful study of facilities and skills available in the new location may indicate revision of methods. Frequently, expense of dismantling and reinstalling existing facilities will justify replacing machinery that is only partly obsolete. Time schedule of moving may force new facilities to be in operation before old ones are released. If a new method is introduced into an existing layout, expense of rearrangement and employee training is obviously chargeable against the expected saving. Where a new location is involved, moving expense and employee training are frequently independent of method. Analysis of fundamentals presents exceptional opportunity for manufacturing cost reductions in relocated layouts.

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Value of land, contour and area available, transportation facilities and their relation to raw- and finished-material markets influence type and shape of building, number of floors, and type of storage, material-handling, and waste-disposal facilities. A level site may not be the best with bulk products where gravity flow can be used. This was recognized long ago in the old flour and feed mills nestled on sloping banks of small streams throughout the East—with one wagon road for receipt at the headrace second-floor level and another for delivery at the tailrace level of the floor below.

The price, skill, and volume of the local labor market and trade practices in the district influence application of labor-saving devices and precautions necessary to prevent interruption of work. Prevalence of single or multiple shifts, extent to which women are employed, and their permissible working hours will influence cushion storage and type of equipment. Presence of other industries in the district using similar skills is valuable and accounts for the location of many small shops. The automobile industry has brought many other sheet-metal products factories to Detroit. The firearms and textile-machinery plants of New England cradled its machine-tool industry. Labor supply and buying methods keep the garment industry in the New York area.

Short available time before starting production, short period of use, or wide seasonal fluctuation indicates selecting conventional or well-tried methods with available or easily procured equipment having considerable salvage value. Under these conditions dependence is placed on existing feeder sections and outside suppliers. An unusual operation or process requiring development should be shunned for any product that must be produced quickly to meet a changing market. Develop it for the next model or introduce it gradually over a series.

The answer to these five major questions as applied to any manufacturing problem will determine the type or even the necessity for any layout. Manufacture of the product in existing layouts in connection with other products, either in whole or in part, may be desirable.

FROM JOBBING TO MASS PRODUCTION

Our experience has been that, as products gain in popular acceptance, they tend to pass through various stages ranging from use of existing facilities to approximately complete straight-line production or the independent plant, including certain feeders, but very few run the entire gamut. Careful classifying and grouping may give diversified products many of the advantages of straight-line or mass production and still retain flexibility of control. The grouping selected should have large enough elements to permit efficient use of machines, equipment, and supervision. Two medium-production machines, located one in each of two smaller groups, will frequently be more efficient than one high-production machine requiring transportation, accumulation between runs, frequent set-up costs, and elaborate tooling. Several styles can sometimes be produced simultaneously by grouping lower-production units

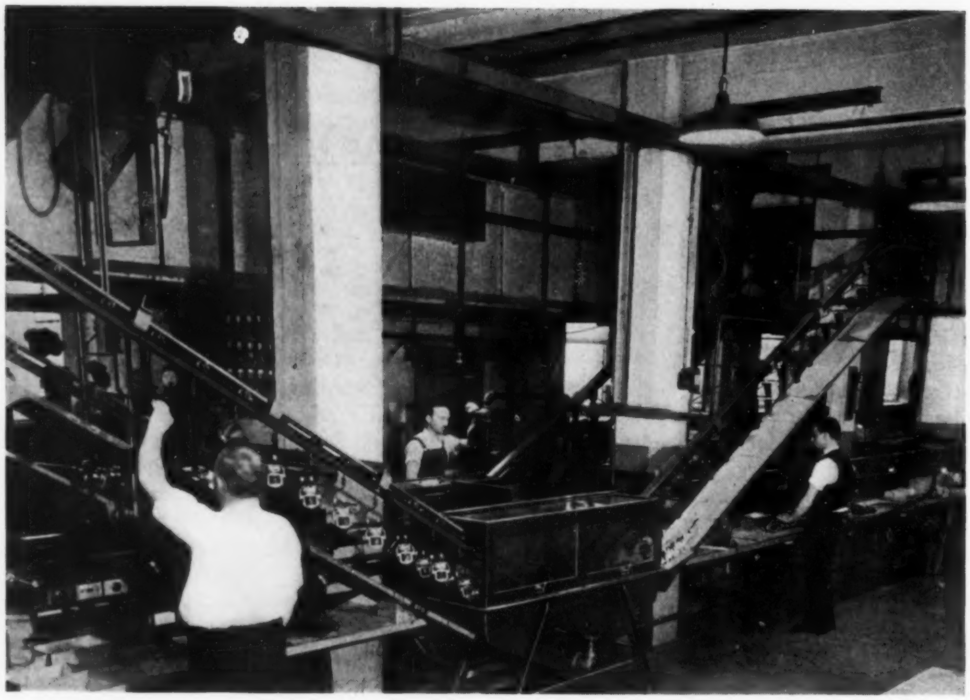


FIG. 1 PROCESS FOR DIPPING AND BAKING THAT FORMS A PART OF THE WATTHOUR-METER ASSEMBLY LINE

in a series of consequent operations with automatic feeds to the longest ones only. Here, the operator becomes his own conveyor to a large extent. Simple rollers or hoists are frequently desirable to prevent lifting of heavy parts. The general handling to and from these groups is, of course, independent of these arrangements.

A problem of this type in machining motor frames with two brackets and core diameters and several frame widths was solved at East Pittsburgh by the layout described below. Time study indicated that the boring operation and its setup controlled the output. Castings are delivered by industrial cars from foundry or rough storage and go to a milling machine equipped with a fixture holding two frames and adjustable so that either one or two sizes can be machined simultaneously. After the feet have been milled on the bottom, the frames go to the automatic boring machines. Changes on these machines to accommodate different widths are simple, but diameter changes are more complicated. One machine is frequently kept in operation on each diameter, and parts of one diameter accumulate on a storage conveyor. Those of the other diameter pass directly to the multiple-spindle drilling and tapping machines where changes are frequently and quickly made. Boring of small lots and round frames is done on two turret machines. As the milling, turret, and some of the drilling machines are provided with power feeds, this particular setup can be operated by a group of workmen which varies in size, according to the fluctuations in production demands, and may, should the necessity arise, be engaged in the machining of as many as four types of frame simultaneously.

Space previously considered unsuitable was found for this layout by increasing the light intensity from 6 to 16 ft-c and shifting the industrial track to the side of the bay to permit effective grouping. Otherwise, this setup could not have been located adjacent to other similar groups and the delivery chain conveyor carrying assembled frames and stator cores to the winding section.

We believe that we are conforming to a general trend by including many typical feeder operations in sequence layouts and providing subfeeders for some individual operating divisions apart from the general service departments. The basic reasons for this condition are:

(1) Increased size of both assembly and feeder units has eliminated former close personal contact and caused increased costs in double inspection, material handling, and storage.

(2) Standard specifications, better metallurgical control, and improved fabrication machinery have given more uniform basic materials.

(3) We have more scientific knowledge of processing and better control instruments and mechanisms. We can, and frequently do, control all process units from a central laboratory but locate the actual production units in separate places. This has been done with plating and polishing, heat-treatment, winding, dipping and baking, paint and lacquer finishing, and similar operations. Fig. 1 shows a dipping and baking process inserted in the production line for watthour meters at the Newark works. Very little space on the line is required as the electrically heated oven is suspended from the ceiling.

(4) Previous objections to locating units in production lines have been eliminated by improved equipment. Oil, gas, electric, and high-pressure steam heat; conveyor systems, and improved ventilation, including air conditioning in small or large units, all have helped.

In determining whether to depend on central feeders, outside suppliers, or decentralized units, we must analyze the feeder items in the same way as the main product for permanence of product market and design, capital outlay required, and salvage value of any surplus material should the item be discontinued. Special training of workmen or development of equipment that may be required and facilities that are available elsewhere are considerations of major importance.

Probably no industry had as radical and rapid design changes as radio in its first ten years and, while conveyorized final assembly lines were common, few industries have depended as much on parts manufacturers. Development of the all-steel refrigerator cabinet with elimination of elaborate dry-kiln and woodworking departments caused manufacturers who were familiar with sheet-metal fabrication to install cabinet departments.

Plants located in an industrial district frequently will find specialists to handle peak loads of standard products or complete items. This is particularly true of hardware, metal-stamping, screw-machine and wood products, and packing material and cartons.

The natural feeder sections of any plant are those requiring large volume or special processes or having nuisance factors. They can be divided into three general classes on the basis of

whether operations are (*a*) preliminary to machining and assembly, (*b*) associated more or less intimately with machining and assembly, or (*c*) general detail operations.

Group (*a*) includes items frequently obtained from outside suppliers, such as castings, molded plastics, porcelain insulators, copper wire and strap, enameled and covered wire, die castings, screws, bolts and nuts, forgings, and similar products. All require large volume or special technique for low-cost operation.

Group (*b*) items are more intimately associated with machining and assembly but have similar characteristics to those of the preceding group. They are, therefore, less frequently outside items but usually, although not always, are central feeders. They are supplied by woodshops, and automatic screw-machine, metal-stamping, plating, vitreous enameling, heat-treating, and polishing departments. Occasionally, some of these are included in divisional subfeeders or production lines.

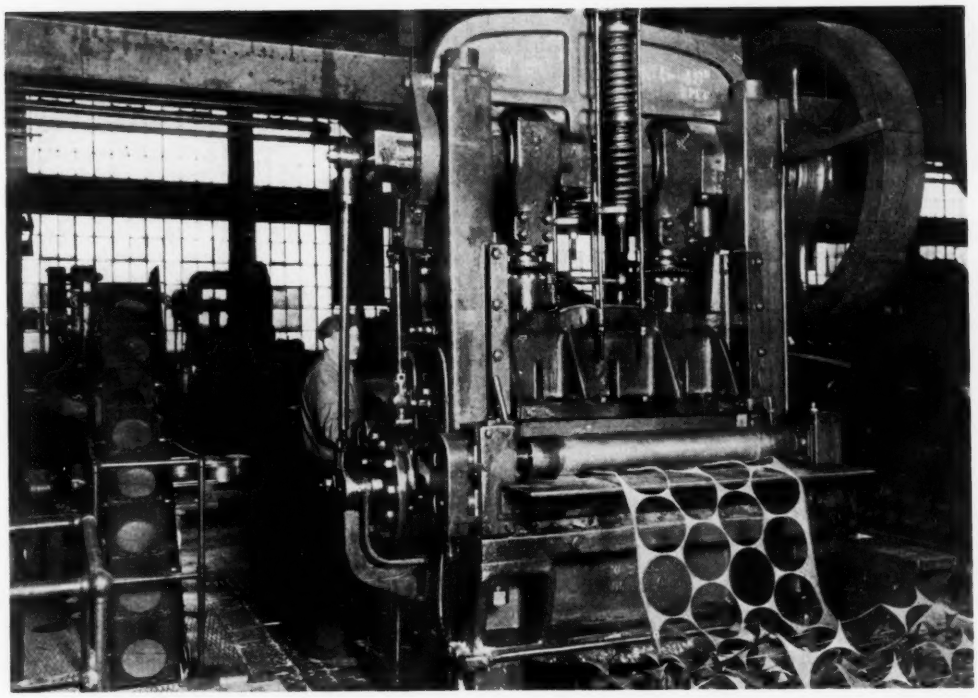


FIG. 2 BLANKING DISKS FROM WHICH STATOR AND ROTOR PUNCHINGS ARE MADE

(These disks or "cookies," after being cut from a sheet in the central feeder section, drop through the floor, are picked up by the elevator at the left, and stacked, as shown in the background, for transportation to the presses which complete them by punching the winding slots, rivet holes, and shaft bores. These cookies are easily transportable, and this manufacturing procedure obviates the possibility of damage to these delicate parts as the presses that punch them are located adjacent to the core-assembly section.)

Practice varies considerably in group (*c*) which includes general detail machining, grinding, painting, dipping, and baking. These operations are frequently performed in divisional subfeeders or the production line.

Difficulty of handling scrap and sheet and maintenance of dies have usually kept metal stampings in a central feeder. We have made subfeeder sections for metal stampings in a number of divisions, particularly for final piercing or forming.

Motor laminations require large quantities of sheet steel and have bulky scrap. The finished punchings are delicate and easily damaged when not assembled into stator and rotor cores. In several cases, this problem has been solved by blanking easily transportable plain disks or "cookies" in the central feeder section and locating presses for finished punchings and the core assembly adjacent to the winding section of the assembly department. Fig 2 shows the blanking press in the central punch shop with the automatic elevator and cookie-stacking device. Stacks of cookies ready for shipment can be seen in the background. The scrap problem here is easily solved by baling presses. Both rotor and stator punchings are made from the same cookie, and the only scrap is from winding slots, rivet holes, and shaft bores.

Separate punch-press sections are located in the mica and micarta departments, and winding departments are frequently provided with their own presses for cutting fiber and other sheet-insulation materials. Recently, a step farther forward has been taken with the installation in a circuit-breaker and panel-board department of three separate press sections for box, trim, and breaker-part fabrication, and bus-bar and panel parts for panel-board assemblies.

The central metal-stamping feeder section at East Pittsburgh is really a number of punch shops with common die-storage and maintenance, material-storage, and shearing facilities. It has a number of special groups, including large and small box fabricating with welding and assembly in sequence with the presses and several lamination sections, some of which assemble cores.

APPLICATION OF LAYOUTS TO TYPICAL BUILDING DESIGNS

The typical general machine shop is characterized by a central crane bay with side bays and galleries on one or both sides. Omission of the side bays and galleries leaves the single central bay, while if the crane and galleries are eliminated, the building is designated as the light monitor type. All these designs have a central aisle in each bay and a relatively high length-width ratio, both of which restrict freedom of arrangement for motion economy in part manufacture and subassembly grouping with relation to final assembly. Side-bay areas can be improved by moving the aisle to one side or the other of the bay. Layouts in all buildings of this type tend to be of the "string-bean" variety, long and narrow, wasteful of floor space, and difficult to supervise or to group any but very small machines efficiently. Where the site permits, the multiple alternate high and low bay construction is usually more efficient, and a similar floor layout can be secured with sawtooth-roof construction.

In older plants, rows of narrow buildings with courts or yards separating them are found frequently. A similar situation existed at East Pittsburgh, where a building with a crane bay and galleries and an adjacent structure with only a crane bay had an intervening yard. By roofing over the yard and removing the abutting sidewalls, the smaller building, the former yard, and the side bay and gallery on one side of the larger structure were made available for a new layout that could not be accommodated under the old arrangement.

In multiple-bay buildings, relocating the aisle along one side of the structure, particularly if it is a multistory one, will provide a flexible layout with space economy and conveyor facilities. Where stairways and elevators are located on both sides of a building, efficient floor layouts are possible only for small unrelated groups and jobbing work. The efficient layout for a multiple-bay building locates the receiving and raw-stores department on one side of the bay where it can be readily served by the plant industrial railway or by trucks. Parts are manufactured in the center of the bay adjacent to the raw-stores department and where parts produced elsewhere can be received from the parts feeder. The manufactured parts continue across the bay to the assembly department, which is also served by a railroad track and the assembly feeder, and, after being assembled, travel along the side of the bay to the shipping and finished-stores department which has facilities for railroad or truck shipment.

FLEXIBILITY OF INSTALLATION, AN IMPORTANT FACTOR

With rapid development and annual models playing a greater part in manufacturing, flexibility of equipment and its installation is of increasing importance. The highly special machine is approached with extreme caution, and its salvage value and convertibility carefully considered.

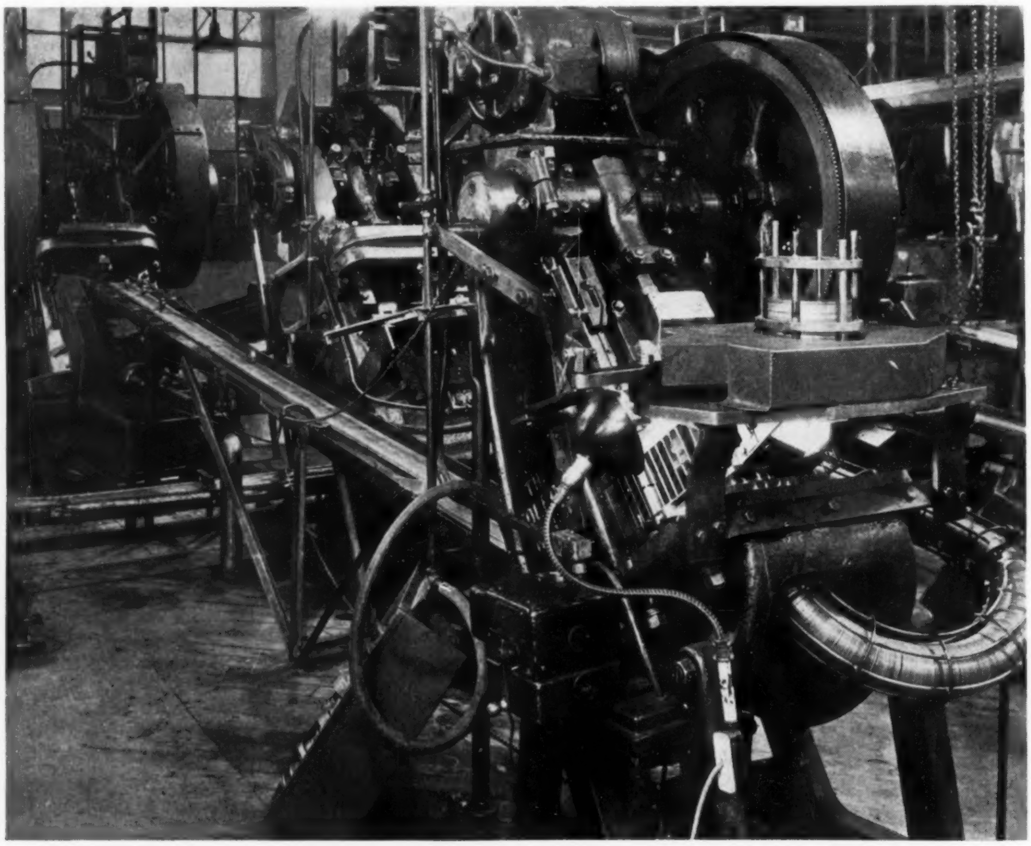
In installing machines, particular care is taken to make all piping, guards, wiring, motors, and control devices on the unit basis and to plan the distribution system so that rearrangement usually means merely loosening a few bolts and reconnecting main wiring and piping. Liberal proportioning of distribution lines through machine shops and assembly departments is sound economy because the next occupant of any given space can never be predicted. Some large machine tools have been placed on a polyphase cord-and-plug system like an iron or a toaster so that they can be moved to the job or rearranged in sequence by simply changing a few screws. Extra precautions are necessary for circuit protection with this arrangement. Cord-and-plug connections were also applied recently to small riveting and drilling machines in the assembly layout for small circuit breakers. In this case, all bench machines are mounted on standard-length unit benches. To change the sequence of assembly operations, the plug can be pulled, the screws loosened, and the benches rearranged quickly and at practically no expense.

TIME AND MOTION STUDY AND FLOW SHEETS

In preparing a layout, a flow sheet or diagrammatic layout of parts, indicating trips to feeder sections, accumulations of work in process, and the like, is of great value. Complete motion study is desirable in many cases if an existing layout is to be expanded or rearranged.

Time studies of operations involved permit balancing the load on machines where one machine must be assigned to a number of parts as well as when it is in continuous production. The layout engineer must go behind the time study and see the operation sequence as a whole, questioning the reason for each step and seeking better combinations. Here, the motion-analysis approach is valuable even when complete motion studies cannot be made.

Plant layout today is a continuous study that vitally influences every phase of manufacturing operation. Design and equipment changes come more frequently than formerly, and the layout must move with them.



SEMIAUTOMATIC LAMINATION SETUP FOR ROTOR AND STATOR PUNCHINGS AND CORE ASSEMBLIES

PROCESSING RESEARCH *for* AGRICULTURE

By JOHN P. FERRIS

KNOXVILLE, TENN.

IN HIS presidential address[1] at the Annual Meeting of The American Society of Mechanical Engineers in December, 1935, R. E. Flanders pictured America's problem of conquering its new frontier, a greatly raised standard of living, commensurate with our national resources. The old frontier, which passed into history a generation ago, consisted of the development of new land areas. With a state educational and research institution as host, representatives of business are here, meeting with representatives of the agricultural- and the mechanical-engineering profession to discuss some things that engineering can contribute to the conquest of the new frontier as it exists in agriculture.

Our national destiny is still linked to the land. Several great divisions of our economy, associated with cotton, wheat, corn, meat, dairying, forests, and others, have been brought about by the different ways in which our soil resources have been used. The people of this continent, of course, got their start on the land itself, and some of these differing economies appeared before we had much of any industry.

All over the world, certain regions developed almost entirely on the shipment of raw materials. Among them are the South with its cotton and the Northwest with its wheat. A raw-products area is generally a specialized area. The outgoing commodity is sold at low world-market prices, and the goods needed for living are purchased from industrial and commercial regions. Little "labor value" is added to the commodity which is shipped from the raw-products area by its own people. On the other hand, they must pay for a comparatively large "labor value" in the manufactured goods they buy. To get a cheap automobile, for instance, a timberland owner must exchange about 250 tons of pulpwood. Thus, people in such areas must supply large quantities of raw products, and one result is a too rapid use of their resources—mineral, forest, and soil. The actual situation in some of our cutover timber regions is a warning that other "economic deserts" will follow the exhaustion of resources.

INDUSTRIES BASED ON SOIL-BORN ECONOMIES

Many of our greatest industries grew upon their association with one of the nation's soil-born economies. The wheat belt for instance, furnished the base for the farm-machinery industry. This market, in turn, was one of the cornerstones of the steel industry.

The meat economy, that of dairying, and others are very different from those of cotton and wheat, in that they rest on a cover-crop base and can, therefore, more easily be adapted to maintain the fertility of their soils and to bring a higher level of income. In the production of beef cattle, we also take advantage of a miracle performed by the plants which the animals eat. Most of the food that plants make comes from our inexhaustible supplies of air and water and not from the soil at all. As a consequence, only 6 per cent of the materials in a beef carcass are minerals and nitrogen originating in the soil; 94 per cent we get "for nothing" as far as the land is concerned.

A region based on dairying and such diversified products as fruits and vegetables has another advantage. As in the case of manufactured products, a comparatively large "labor value" may be added for the skill involved in quality production and in effective marketing practices.

In the first stages of America's economic development, ***basic soil economies shaped manufacturing developments.*** Why did the McCormicks manufacture their reaper at Chicago? Because Chicago was a commercial outpost in communication with the great wheat area and because coal and steel could be cheaply shipped from Pennsylvania on the Great Lakes waterway, and later, on the new east-west railroads. Settlement of the industrially skilled immigrants from Europe naturally followed these same transportation routes.

Now, however, we have come to a new stage, one in which we can look to industry to take a hand in shaping the basic economies under which our people live. Industry can, to a much greater extent than ever before, establish the location of its demand for the materials which it buys, and so exert a guiding force on the location of their production.

Another recent trend in industry is a shift of interest to soil products for its raw materials, in addition to minerals and metals. Unlike minerals, which dwindle in quantity and become more costly, the supply of agricultural and forest materials can be maintained by following proper practices year after year.

ELIMINATING WASTE AND SPOILAGE BY FREEZING

Elimination of waste and spoilage is one field where processing can effect major savings. A large fraction of all perishable products grown in the United States is either wasted or lost through spoilage. This enormous loss can be greatly reduced by freezing for the market, with benefit to both the farmer producer and city consumer.

Much attention has been given to improvements and refinements in refrigeration machinery for urban business and for the city dweller. Only recently have mechanical and specialized refrigeration engineers begun to attack the problems of developing simple rugged refrigeration equipment suited to the needs of the rural area. How much still remains to be done on refrigeration's agricultural frontier is indicated in an article[2] that was published about 18 months ago.

Further development of quick freezing is one such opportu-

[1] "New Pioneers on a New Frontier," by R. E. Flanders, Mechanical Engineering, vol. 58, 1936, pp. 3–6.

Presented at the Agricultural Processing Meeting, New Brunswick, N. J., Feb. 26, 1937, held under the joint auspices of the Process Industries Division of The American Society of Mechanical Engineers, the American Society of Agricultural Engineers, and the Farm Chemurgic Council.

[2] "Farm and Community Refrigeration in Rural Readjustment," by W. R. Woolrich, R. B. Taylor, and M. Tucker, *Refrigerating Engineering*, vol. 30, 1935, pp. 330–334 and 356.

nity. Consider its relation to the problems of strawberry growers, for instance. Over eleven million crates of strawberries, most of them in the form of highly perishable fresh fruit, were delivered to the American market in 1935. Four southern states shipped over one quarter of this quantity in about a month. The market cannot absorb the product in this short time without a drop in value, and prices often fall below the cost of production. In one state alone in 1933 and again in 1934, over a hundred thousand crates of strawberries remained unharvested due to glutted market conditions. Frozen fruits and vegetables have become an established product on the market, and the demand from certain types of consumer for frozen foods is increasing rapidly. Freezing should provide a dependable market for the producer at prices which are relatively stable throughout the year.

Freezing in barrels with sugar is not altogether satisfactory. For one thing, it must be done in fixed cold-storage buildings. Berries are best frozen within a few hours after they are picked. Various developments are under way to make freezing processes available to producers who do not live near large cities that have commercial freezing facilities. Movable machines, carried from one community to another, can make it possible to schedule freezing of a series of fruits and vegetables through the season, as they ripen.

Drying of agricultural products involves the mechanical engineer's basic knowledge of heat transfer, evaporation, and the circulation of air to which the agricultural engineer contributes specialized knowledge of agricultural needs, required design features, and the economics of use. In addition to dehydration of human foods, there is the difficult problem of developing low-cost hay driers. Some possibilities are indicated by J. W. Weaver, Jr., in his paper "Development of a Low-Cost Hay Drier."[3] Promising results have been obtained with equipment costing approximately $300. At such a price it would be within reach of a large number of farmers.

RESEARCH IMPROVES TOBACCO, SWEET POTATOES, AND SORGHUM

Requirements for humidity and temperature control in curing tobacco are being studied at the University of Kentucky's agricultural experiment station in cooperation with the college of engineering. The U. S. Department of Agriculture's tobacco experiment station at Greeneville, Tenn., and the agricultural-industries division of the Tennessee Valley Authority, are cooperatively developing economic processes for using electricity in tobacco curing. The importance of better methods is indicated by an estimate that the loss in only one market due to poor curing is about $300,000 in a bad curing season. Control of temperature and humidity is also required in storing sweet potatoes. Nearly half of the sweet-potato growers in the South, other than those using certified seed, realize a poor return on account of infections such as black rot.

Another development toward greater income for farmers is in connection with processing of sorghum, which for two seasons has been carried out on a small pilot-plant scale under the supervision of the agricultural experiment stations of two of the Tennessee Valley states. This has demonstrated that, where a substantial quantity of sorghum syrup is being produced in a rural community, improved methods will make it relatively uniform in quality, consistency, and noncrystallizing characteristics, and generally superior to the average run of farm-produced syrup. Farmers found that, by marketing the syrup in smaller and more attractive containers, they could earn a profit on the increased cost of the packages and labels. They received, in 1935, up to 75 cents per gal net, as compared with 45 cents for ordinary syrup. Here, farmers are being helped to do a better job on a product that they were already making and, thus, get a greater and more stable cash return without increasing the quantity marketed. General adoption of the method could mean a considerably increased farm income in southern states, where millions of gallons of sorghum syrup are made annually.

[3] *Agricultural Engineering*, vol. 18, 1937, pp. 25–27 and 46.

PROCESSING DEVELOPMENTS AID COTTON GROWERS

New processing developments promise help in readjusting the one-crop cotton system. Cottonseed crushing, for instance, already produces oil and other by-products of great value; research can increase this return further. Also, it may be feasible for soybeans to be grown as a substitute crop on the flatter cotton lands and processed in addition to cottonseed in the existing mills, thus producing soybean oil, meal, and meal cake. Soybeans are planted late in the season, and cropping systems are being studied which would permit a soil-protecting cover crop to be grown in the same year. A third agricultural source of oils needed in industry is flax, from which linseed oil is obtained. Furthermore, recent research indicates the possibility of spinning the short seed-flax fibers on cotton machinery, which would, if successful, utilize excess textile-mill capacity in producing new fabrics for which the demand seems to be growing.

Experimental work carried on for several years at the engineering experiment station of the University of Tennessee[4] indicated that cottonseed can be processed in a new manner, using pressure cooking, to give an appreciable increase in oil yield, improved quality, and greater uniformity. As a result, a cottonseed-processing section was organized under the A.S.M.E. Process Industries Division, and, for two years, the Engineering Foundation supported the research. At present, tests are being carried on by the University on a pilot-plant scale with the cooperation of the Tennessee Valley Authority. Much of the equipment was contributed by the industry.

Since the crude products of cottonseed crushing—oil, meal, meal cake, hulls, and linters—were worth $168,000,000 in a recent year, any improvement in efficiency of recovery of these commodities, or any processes affecting favorably the quality of the products, will represent a large saving, much of which should find its way to farmers.

If the improvement in the oil-extraction process, now under development, is successful, it should greatly benefit hundreds of small rural mills as well as the larger mills. The former are, perhaps, in the best position to exchange cottonseed meal locally for the farmers' cottonseed, thus encouraging introduction of livestock which is so important for permanent stabilization of cotton agriculture.

Beyond its cash value, cottonseed carries protein, containing the plant-food element, nitrogen, and also mineral compounds which together make it valuable as a concentrated feed for animals. When fed locally to livestock, as much as between 75 and 85 per cent of the fertilizer content of the meal returns to the soils from which it was taken, rather than being continually drained from the area. Excessive drain of fertility from the cotton belt by exportation of cottonseed and meal over the last seventy-five years has been a major cause of soil exhaustion. When livestock is marketed, on the other hand, cash income is produced with little loss to the soil. This is because, in the bodies of animals, nature "processes" other food elements that animals eat, elements that the plant draws from our inexhaustible supplies of air and water. That the meal be distributed

[4] Manual of "Mechanical Processing of Cottonseed," by W. R. Woolrich and E. L. Carpenter, University of Tennessee Engineering Experiment Station, Knoxville, Tenn., 1935, 154 pp.

locally to the greatest possible extent and that cotton farmers introduce livestock into their farm-management plans is extremely desirable. Livestock means more grass and pasture, cover crops that control erosion.

As increasing quantities of soybeans are produced in the cotton states, the importance of processing them in the same equipment that is used for cottonseed becomes apparent. It should enable cottonseed mills to operate for a longer portion of the year with a consequent reduction in cost of processing each of the commodities. Before this program can expand, however, suitable types of soybean must be grown, and machinery for handling them must be made available for use by the farmer.

With the relative demand for straight cotton fabrics decreasing, other fibers, such as flax, which might be handled on existing textile machinery, become important. But whether flax growing can be adapted to a system of agriculture readjusted for land conservation must first be known. One of the southern agricultural experiment stations is investigating some of the agronomic problems to determine whether areas in its state are suited to the economical production of flax and its competitive position with relation to other crops in the region. Under a cooperative experimental program, the textile laboratory of this state's engineering college is attempting to develop flax and mixed yarns suitable for use in the cotton-textile industry. They report that the ultimate fiber of flax seems to be short enough for this purpose and that 100 per cent flax yarn can be spun on cotton machinery. Using such yarns, commercial processes for weaving linen and cotton-linen fabrics are being studied.

ENGINEERING'S CONTRIBUTION TO AGRICULTURE

How can engineering enlist for service on the new frontier? A few of the many needs and opportunities for engineering to strengthen our agricultural economies have been referred to. Such a development as hay drying constitutes an engineering contribution to better farm operation as well as to soil conservation, for it promotes the extension of cover crops. Others are concerned with removing limits to disposal and industrial use of farm crops in manufacturing and increasing farm income. Utilization of existing crops is not enough. Many conventional cropping systems involve too much emphasis on a single cash crop. Experience of a century has demonstrated the danger in this situation. Diversity is needed both for economic stability and for the creation of a variety of opportunities corresponding to the various abilities and talents of our people. By developing the new facilities needed to accomplish these things, engineering can open new avenues of progress, along which agriculture can advance.

Mass-production industry is already well established. In addition, we greatly need more of a type of local manufacturing that is "indigenous"—the product of local leadership and brains, local capital, and nearby markets. This should be new industry based largely upon new methods and creating new wealth and new jobs. Great cities need not fear this type of business development. No migration of industry is involved. And, as the National Industrial Conference Board points out, the new production is matched by new markets for goods from other regions.

FUTURE OF INDUSTRY IS IN THE LABORATORY

Industry seeks its future in the laboratory. Great corporations turn to their own magnificent research staffs to develop new technical processes, by which they can use agricultural materials. Thus have come rayon and cellophane from cotton and wood, Masonite from stumps on cutover forest land, and better enamels, using soybean oil and solvents made from waste molasses. Few small manufacturing enterprises, however, can maintain adequate laboratories. Naturally, they seek access to the public technical laboratories in their state universities for research assistance and guidance.

Seventy-five years ago the Morrill Act was passed, establishing a nation-wide system of instruction in agriculture and mechanic arts in every state of the Union. It was signed by President Lincoln. The essential companionship of agriculture and industry was thus recognized three quarters of a century ago. Since 1862, the agricultural colleges have been studying and developing the best uses for the agricultural resources of each state. As a result, the Hatch Act in 1887, the Adams Act in 1906, the Purnell Act in 1925, and the Bankhead-Jones Act in 1935 have established a national policy of encouragement to the states in this valuable work.

ENGINEERING RESEARCH TO IMPROVE FARM INCOME

Likewise, a number of the engineering colleges have been working on the improvement of farm income through research on engineering problems, especially those concerning conservation and the processing of raw materials. In the Tennessee Valley region, the demand for such developments was greatly increased as a result of the regional program of water control and soil conservation. Many of the necessary engineering investigations connected with soil conservation and watershed protection were undertaken jointly by existing institutions and the Tennessee Valley Authority, as research laboratories and supervisory personnel were already available in the colleges. For the nation to look to its engineering colleges in this way for substantial participation in the solution of national problems, has, unfortunately, been unusual, although, for half a century, the agricultural colleges have been playing their part with some federal support.

On the other hand, many publicly supported engineering colleges throughout the nation have largely restricted their research programs to various fields of fundamental science and to problems which were of interest only to special groups. Apparently, only a few have thought of themselves as state agencies for broad and comprehensive study of the best uses for industrial resources in their respective states. Paralleling the work that the agricultural experiment stations have been doing for years in exploring the best uses for agricultural resources, the state engineering experiment stations have an opportunity to assume leadership in developing well-considered research programs in such fields of processing the raw materials of their own states as no single industry can afford to undertake by itself.

Technical investigations are not enough. As Secretary of Agriculture Wallace has said, in order to prevent the exploitation of producers or would-be producers, engineering research should

> . . . work hand in hand with hard-headed cost accounting and commercial research . . . . Although a product may be made successfully in the laboratory, this does not say that it will necessarily be profitable to producers. The final step is testing it out under practical conditions on a commercial scale. . . . When the farmer supplies raw material to industry, it must be at a price that will be profitable to the farmer.

And, of course, intercommodity competition must be taken into account.

By increasing the diversification, security, and productiveness of our agricultural regions, engineering helps to open the new frontier.

HUMANISTIC SUBJECTS

in the ENGINEER'S TRAINING

By J. W. Roe

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VARIOUS studies made by independent groups concur in showing that approximately two thirds of the engineering graduates are engaged, by the time they have been out of college for 15 years, in work that is primarily executive in character. A technically trained man if he is good, and because of that fact, will reach a time when he must do his work through others, rather than with his own hands. Though his work is still in the technical field, inevitably, he must deal with men in increasing numbers.

No important technical problem is free from implications that reach far beyond pure technology. It affects economic relations with the public and is affected by public reactions. It affects workers not only in his own enterprise but also in competing ones, and it may affect the interests of an unknown army of consumers. These reactions may govern the success or failure of his work, independent of its technical merit. The engineer, therefore, who has technical knowledge only, is but half equipped. To reach full usefulness to himself, to his employers, and to society, he should have not a smattering, but a sound, sane working knowledge of economics, industrial history, and industrial relations. These should be part of his education and treated not as frills, "culture subjects" on the side, but a part of his necessary training; and they are just the subjects that he may not forget when he tucks away his diploma.

Let us first consider economics. The capitalistic system, under which the engineer operates, is under fire everywhere. He should know what it really is, how it came about, how it works, what it has accomplished, and wherein it has failed, its strength and its weakness, and how to defend that in it which is sound. He should know what have been its effects on the standard of living and the creation of wealth and its distribution. He should know the relationship between production and consumption. Increased consumption or a steadily rising standard of living cannot occur without an increasing production and a wider distribution of it. On the other hand, increased production is folly without increased power to buy. He should know something of business cycles and their effects on labor as well as on capital. He should know the advantages and disadvantages of standardization, specialization, transfer of skill, division of labor, and, most remorseless of all, the law of diminishing returns. Any advantage, if pushed too far, can become a detriment. This, by the way, applies both to labor and to capital. These subjects are not theoretical. They run through all he does.

Industrial history is another subject that he should know. The industrial revolution, which ushered in the machine age, is a gold mine of experience for every industrial executive today. Forces were let loose both for good and evil. Wealth increased by leaps and bounds, but all was not well with society, and years have been required to undo some of the harm then done. The bitterness in England today between labor and capital is a holdover from the abuses of that day. Some may rail at the shortcomings of labor unionism, but when they know the conditions from which it sprang, indignation merges into charity. The industrial revolution gave rise to unionism. Anyone who deals with workers should know the origins of collective bargaining and its development in this country as well as in England.

To act intelligently as an executive, one must know the rise and fall and migrations of industries and the rise of mass production, of the interchangeable system of manufacture, of power and power-driven machinery, and of their effects on standards of living. These can all stand investigation. They can, and should, be beneficial, but they must be dealt with intelligently. Tied in with these is the problem of technological unemployment with all that this involves. History shows conclusively that invention and technological advance ultimately make for the welfare of all and, perhaps most of all, for the working class; but it also shows clearly the distress that may accompany the introduction of these improvements. It is part of the engineering executive's job to see that his work is done so as to minimize this distress. The more the engineer knows of industrial history, the more intelligently will he do his day's work.

Finally, the subject of industrial relations should be studied. Practically all engineering work involves coordinating the efforts of bodies of men. This involves satisfactory industrial relations and intelligent and fair handling of employer and employee relationships. Every engineer should have a thorough knowledge of labor unionism and employee representation. Collective bargaining is here and here to stay. Instead of railing against it, the engineer must learn to work with it whether he likes it or not. As much education is required for managers as for the workers to have them settle down into a relationship that should be best for all.

Nowhere does the slow-moving law of diminishing returns operate more inevitably than in this field. Beyond a certain point employers and labor can push *any* advantage only to the detriment of their own interests. Both have done this in the past. The employer-employee relationship involves rights which also involve obligations. To push these rights indefinitely in disregard of the obligations is certain to pass the point of diminishing returns. Our industrial relations, all over the country, will be on a sounder basis when all concerned have a livelier sense of their existence.

The engineer needs knowledge of the labor problem in all its phases, wages and wage incentives, hours of labor, development of skilled workers, living and working conditions, security, safety, and all factors affecting industrial relations. Therefore, at least these three subjects, economics, industrial history, and industrial relations, humanistic if you choose to call them so, are not only proper subjects in the preparation for an engineering career, but also are vital to success under present-day conditions.

Address made at a luncheon for personnel officers and engineers, which was held, under the auspices of the Management Division, the Personnel Research Foundation, the Society for the Advancement of Management, and the Psychological Corporation, in connection with the Annual Meeting of The American Society of Mechanical Engineers, Dec. 3, 1936, New York, N. Y.

THE "COMMON LAW" *of* INDUSTRIAL RELATIONS

By E. R. LIVERNASH

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PARTICULARLY in view of the recent United States Supreme Court decisions upholding the Wagner Labor Relations Act, the problems connected with the development of a "common law" of industrial relations are well worthy of our attention. In fact, history may substantiate the statement that the New Deal ushered in a new public attitude in industrial relations; that we passed from an attitude of toleration of collective bargaining on the part of the government—a "hands-off" attitude, allowing laborers the right to bargain collectively if they could and employers the right to refuse, the government being concerned primarily with policing, protecting property rights, and preventing violence—to an attitude of encouragement of collective bargaining.

WHAT IS COLLECTIVE BARGAINING?

If the encouragement of collective bargaining is to remain an established part of public policy, what does this imply? What is collective bargaining? To what extent and in what particulars are the rights of labor increased and the freedom of the employer restricted? In answer to these and many other questions it is advisable to go back at least to the establishment of the NRA, with its now famous Section 7(*a*), and trace the development of the policy of encouraging collective bargaining. Messrs. Lewis L. Lorwin and Arthur Wubnig have ably carried us through these formative days and have summarized the important issues presented to the two early Labor Relations Boards.[1] The Labor Relations Act of 1935 was built upon the experience of these early boards and incorporates much of the "common law," as developed by the Labor Boards, into the law of the land. This review will attempt to hit the high spots, as brought out by Lorwin and Wubnig, of the effect of Section 7(*a*) upon the law of collective bargaining.

Section 7(*a*), giving labor the "right to organize and bargain collectively through representatives of their own choosing" without "interference, restraint, or coercion" by employers, was open to a variety of interpretations. Though hailed as another Magna Charta by labor, and opposed by some employer groups during the hearings before the Senate Finance Committee, the labor provisions did not call forth the hostility on the part of industry that one might have expected. This lack of hostility was, no doubt, in part due to the ambiguity of interpretation. For, while Section 7(*a*) did give labor the right to organize and bargain collectively, it most certainly did not rule out individual bargaining, nor did it preclude the existence of company unions, nor did it expressly designate trade unions as the agents of collective bargaining, nor did it call for the organization of labor in trade unions parallel with the organization of industry in trade associations.

During the early months of code making, organized labor read into Section 7(*a*) a hearty endorsement of the trade union as the only agency for collective bargaining, while the employers interpreted the law as collective bargaining by company unions and a preservation of the right of individual bargaining. The administrator adopted an attitude of "perfect neutrality." The law said that the words of Section 7(*a*) were to be inserted in each code, and inserted they would be, but no additional words of interpretation were necessary. Only in the case of the "individual merit clause" in the automobile code did a word of interpretation get by. But the issue which aroused the controversy over the merit clause could not in fact be settled simply by refusing such a clause in other codes. The issue, whether the labor provisions of the codes in reality placed limitations upon the employer's right to hire, fire, and promote on the grounds of individual efficiency, was in reality ignored, though the President's statement that individual merit could not be used illegally to interfere with labor organization did silence the controversy.

Thus the early months of code making raised several issues and settled none. The words of Section 7(*a*) were in the codes, but what did they connote? Was the trade union encouraged at the expense of the company union? Was union recognition forced upon employers? Was the closed shop legalized or outlawed? What constituted interference, restraint, and coercion? Had the employers' right to hire and fire on the basis of individual efficiency been limited? And, above all, what did collective bargaining mean?

NATIONAL LABOR BOARD

The National Labor Board, called into being because of the prevalence of strikes which were threatening the reemployment program, was confronted with the task of settling the disputes and, in process, interpreting the language of the labor provisions of the codes. The board adopted a technique of calling a strike off as a preliminary to negotiation; asking reinstatement of strikers without prejudice or discrimination; holding an election to determine the representatives of the workers who were to bargain with the employers with a view to executing a collective agreement; and asking that disputes under the agreement be referred to the board for final decision. While this technique proved highly useful, it did not give precise meaning to "representatives of their own choosing," "interference, restraint, and coercion," and "collective bargaining." In the course of applying this technique various formal decisions had to be rendered interpreting these basic concepts.

One of the first problems involved the free choice of representatives and interference with that freedom. The basic issue was whether the employees had absolute freedom in the choice of representatives or whether the freedom was qualified. Were the employees, for example, restricted in their choice of

[1] "Labor Relations Boards," by L. L. Lorwin and A. Wubnig. The Institute of Economics of the Brookings Institution, Washington, D. C., 1935, 477 pp.

One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

representatives to fellow employees or could they designate outsiders? The board decided in one of its first cases and consistently maintained that choice was not restricted to fellow employees, and that any attempt on the part of the employer to restrict the choice to fellow employees constituted interference.

A more difficult question concerned the possibility of choosing an organization as the representative of the workers. This issue involved more than the designation of certain individuals to act as the representatives of the workers, for, if the employees might designate an organization they would have a choice between organizations, and might force union recognition by the employer. The board, by gradual stages, came to the conclusion that employees might choose a labor organization as their representative. The first development was that union officers or members of a union committee might claim recognition as individuals; later, the board decreed that a union committee in its collective character might claim recognition; finally, the doctrine that a union as such might claim recognition was clearly stated.

VALID AND INVALID COMPANY UNIONS

If a trade union could serve as a representative of the workers, was this also true of a company union? In this connection the board developed a theory of valid and invalid company unions. If there had been interference, restraint, or coercion by the employer, either in establishing or maintaining a company union, such a union was placed in the invalid class. Each decision rested upon the circumstances of the particular case. If an employee-representation plan had been originated by the management, if the workers were not consulted in drafting the plan or in setting it up, and if the workers were not given an opportunity to accept or reject it, such circumstances were deemed to have limited the freedom of choice of the employees. It was not sufficient to have called in the employees to designate representatives under the plan. From an objective point of view, the most important test the board could use was to ascertain whether an election had been held which gave the workers a definite opportunity to accept or reject the proposals of the management, or to choose between the company union and an outside union. Messrs. Lorwin and Wubnig summarize, in part, the board's position as follows:

> The board consistently ruled that any attempt on the part of employers to place limiting conditions on the qualifications of the workers' representatives, or on the manner in which they were to be elected, was contrary to Section 7(*a*) and constituted interference with the employees' freedom to choose their own representatives. This principle tended to make most company unions suspect, for employee-representation plans usually impose restrictions on eligibility to vote and on the right to hold office; allow joint participation by management in the administration of the plan; and place ultimate power of decision on essential matters in the hands of management. But this did not mean that the company union was illegal *de jure*. The conclusive question was whether or not the plan had been established and was maintained through the free expression of the workers' will. If the employees of their own free will chose to conduct their collective bargaining through such a plan, that was their privilege under Section 7(*a*). If, in contrast, the plan was foisted upon the workers by the management, the employer was guilty of "interference."

Elections were thus an important adjunct to carrying out the board's principles of freedom of choice. They were not simply a means of designating specific individuals or organizations with whom the employer was to bargain. They were a guarantee of free choice. And the expression of this free choice was determined by majority rule. The board, in this connection, found it desirable to rule that a majority of those voting, not of those eligible to vote, was sufficient. This was necessary as a guarantee of absolute secrecy.

Finally, in the consideration of interference in organization, mention must be made of the problem of discriminatory discharge. The board made no attempt to limit the right of employers to discharge, hire, and promote on legitimate grounds of individual efficiency. However, discharge for union activity was regarded as interference. The difficulty was, of course, the determination of the motive for discharge. A test of "antiunion bias and intent" was evolved. This test involved known hostility toward unionism, threats of dismissal for union action, and the service record of the employee.

COLLECTIVE BARGAINING A DUTY UPON BOTH GROUPS

The right to bargain collectively had to be defined by the board, and was perhaps more troublesome than the decisions regarding free choice of representatives and interference. Collective bargaining was ruled to involve, (1) a duality of obligation upon employers and employees, (2) manifestation of a will to agree, (3) exertion of every reasonable effort to conclude bilateral agreements, (4) formal agreements as the end result of the process.

The employer was obliged to meet and deal with the freely chosen representatives, in good faith, for the consummation of a collective agreement; while the employees had the duty of using the strike only as a last resort. The existence of a will to agree did not imply that an agreement had to be reached. However, it was assumed that if both parties showed a coöperative attitude an agreement could ordinarily be reached. If the employer had not impeded the free election of representatives, if he had met with those representatives, heard their demands, and made counter proposals, and if he had allowed for the higgling in the market, and, on the other hand, if the employees had not acted hurriedly and heatedly in calling a strike, a collective agreement would normally result. If an agreement did not result it was ordinarily fairly easy to see where the process had fallen down and which party was at fault. Even under those circumstances where everything went smoothly up to the point of agreeing, and then one or the other party flatly refused, bad faith could ordinarily be distinguished from real differences which were so far apart as not to allow of an agreement.

Some employers insisted that the law involved the right of each and every group to bargain collectively; that the intent was some form of collective-bargaining pluralism—at least that the minority should be considered. However, the board maintained that such a concept would defeat the purposes of true collective bargaining, that it was not possible to have more than one bargaining agency of the workers in a single bargaining unit, the appropriate unit (department, plant, or company) to be determined by the board.

Thus collective bargaining was a duty upon both parties acting in good faith to attempt to reach an agreement. If such an agreement could not be reached, the right to strike still existed as a last resort and the employer was not compelled to reach an agreement. Both parties were morally, though not legally, bound to arbitrate such cases, but "industrial warfare" was not illegal.

Messrs. Lorwin and Wubnig have summarized the "common law" of industrial relations, as developed by the National

(*Continued on page 448*)

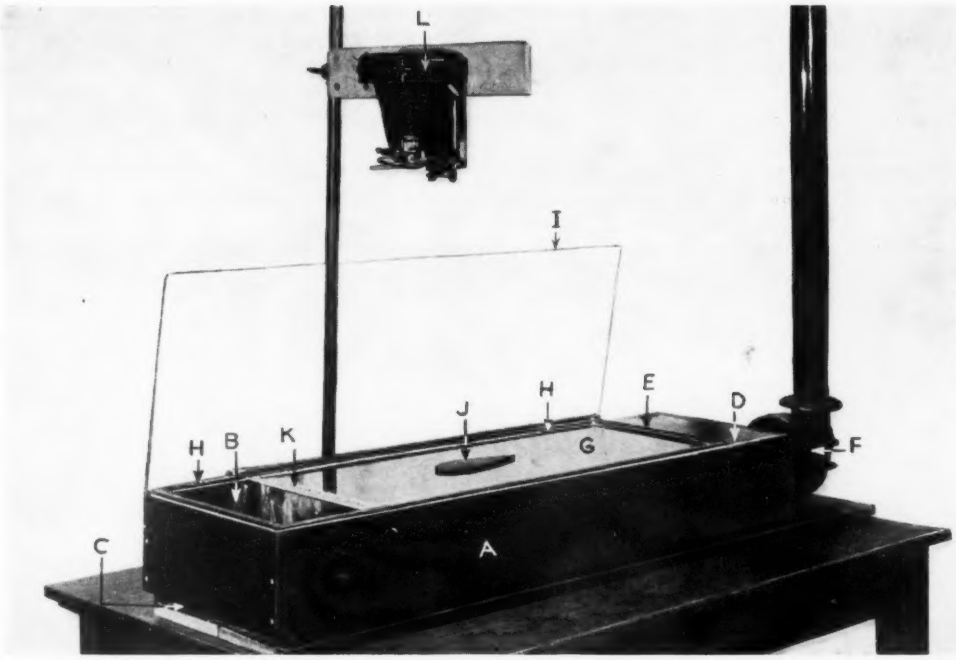


FIG. 1 EXTERIOR OF THE ANALYZER

FLUID-FLOW ANALYZER

A Small Inexpensive Device That Is Simple to Operate

By H. L. PARR

DEPARTMENT OF MECHANICAL ENGINEERING, COLUMBIA UNIVERSITY, NEW YORK, N. Y

RESEARCH work in fluid dynamics, carried on in the last few years chiefly for the benefit of airplane designers, has shown engineers, engaged in many other fields, that a knowledge of some fluid-flow characteristics is necessary for intelligent design of a wide range of apparatus. Such information would result, in certain cases, in a reduction of pressure loss in the fluid passing through a machine, but, in many others, the vital information desired is concerned with the distribution or pattern of the fluid flow. Apparatus has been built with which such information can be obtained, but it is generally expensive, bulky, and difficult to operate. To be of maximum service, such an apparatus should be inexpensive, small enough to be placed in a shop or drafting room, and so simple in operation that almost anyone can use it. To meet this need, the author designed and built the apparatus described in this article. The immediate object of the design was really to illustrate the principles of fluid dynamics to engineering students, but the possibilities of broader use soon became evident. Examples of the type of work that can be done are shown in the accompanying illustrations.

In the usual design of smoke tunnel the size of the duct is such that the air must be run through it at low velocities to maintain laminar flow. If the flow be turbulent, the smoke streams will be dispersed and the flow pattern indistinguishable. Flow at low velocities is easily disturbed by slight air currents in the surrounding space, and a honeycomb system of straightening vanes must be installed in the air inlet.

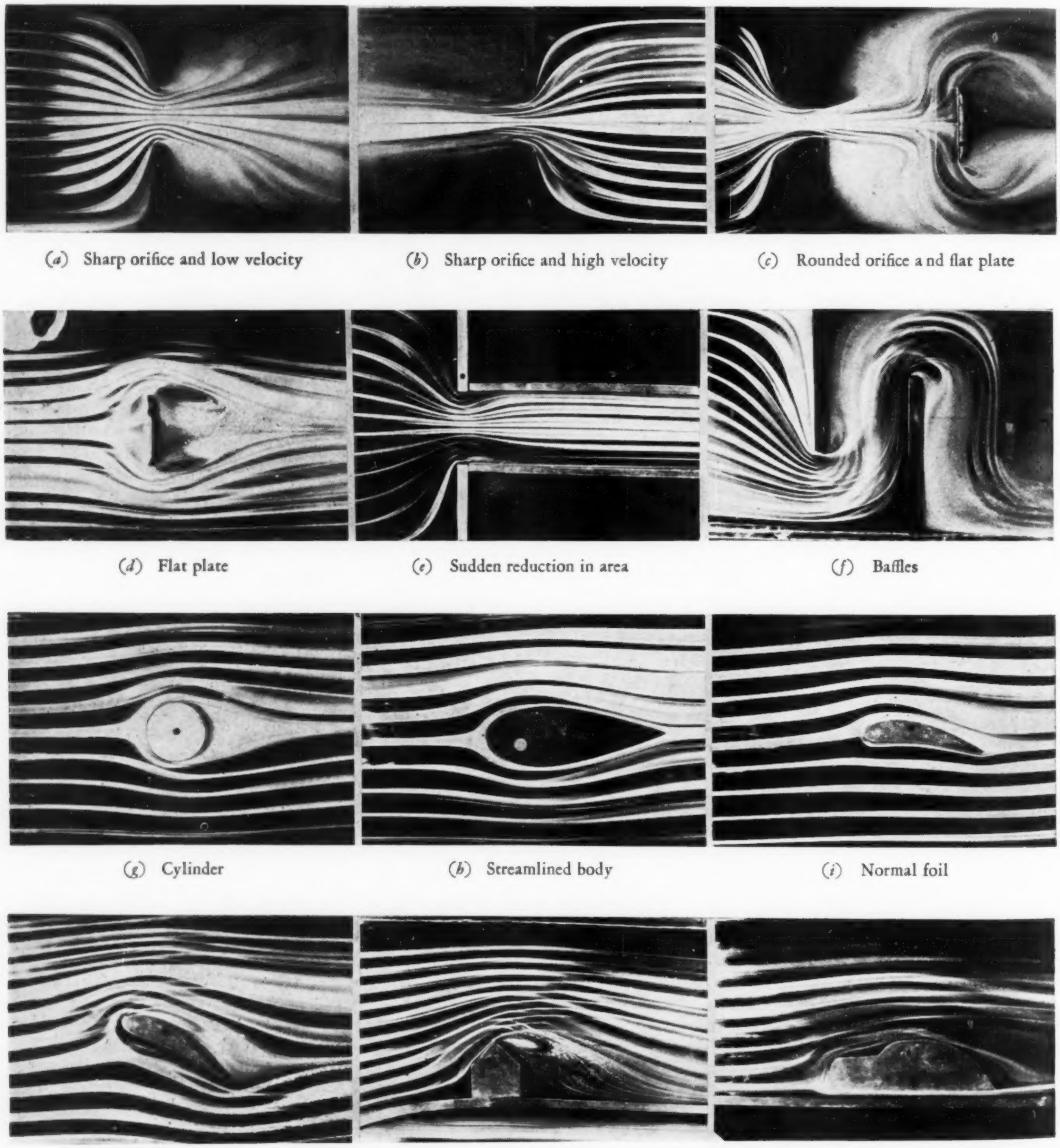
SMOKE FLOWS BETWEEN TWO CLOSELY SPACED PLATES

The main feature of the design of this apparatus is that the flow takes place between two flat surfaces set so close together that considerable air velocities can be used, and little protection is necessary to maintain parallel flow. The details of the construction are shown in Fig. 1. Dimensions given are those of the apparatus shown, but they can be varied widely to suit particular needs. The wooden box *A* is 48 in. long, 7 in. high, and $12^1/_2$ in. wide and is divided into three parts by partitions. That at the left, *B*, is 8 in. long, and the top is open. It is the air inlet, the air entering through the small opening *C* at the bottom of the end. The chamber at the right, *D*, is the air outlet, the air entering through the slot *E*, in the top of the box and being drawn out by the motor-driven fan *F*, which is mounted on the extension of the bottom of the box and connected with *D* by a short pipe. Between the inlet and outlet, is a center chamber that is painted black on the inside to form a background and contains properly shielded lights. A 33 × 14-in. sheet of plate glass, *G*, is let into the edges of the box so that its upper surface is flush with the top. Extending down both sides and across the inlet edge of the box is a strip of sheet rubber, *H*, which is $^1/_4$ in. thick and is cemented in place.

When the 43 × 14-in. sheet of plate glass *I*, which is shown in a raised position, is lowered and rests on the rubber strips, a continuous channel $^1/_4$ in. deep and 12 in. wide connects chambers *B* and *D*.

All models are cut from $^1/_4$-in. rubber sheet, which is the thickness of the channel, and laid on the lower glass plate, as shown at *J*. A collection of models is shown in Fig. 3. Uses of most of them will be readily apparent. Many can be used singly or in combination. Small disks are employed to show flow through tube banks. Flexible strips are used to make up channels of varying cross section, baffles, or to represent the ground for such conditions as are shown in photographs (*k*) and (*l*), Fig. 2. Metal ribbon has also been used to simulate sails on a boat.

Titanium tetrachloride is spread with a dropper in the slotted trough K, Fig. 1, which is shaped and located as shown in Fig.



(*a*) Sharp orifice and low velocity
(*b*) Sharp orifice and high velocity
(*c*) Rounded orifice and flat plate
(*d*) Flat plate
(*e*) Sudden reduction in area
(*f*) Baffles
(*g*) Cylinder
(*h*) Streamlined body
(*i*) Normal foil
(*j*) Stalled foil
(*k*) House
(*l*) Automobile

FIG. 2 PHOTOGRAPHS OF FLUID FLOWS FOR VARIOUS MODELS AND CONDITIONS

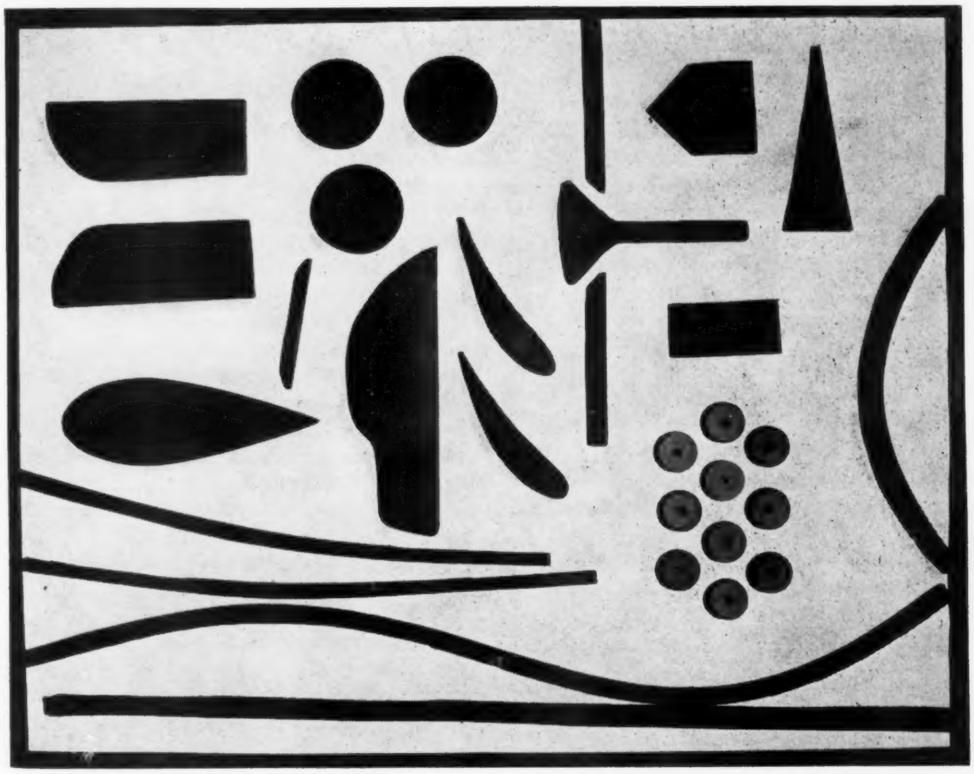


FIG. 3 COLLECTION OF RUBBER MODELS USED WITH THE ANALYZER

4. It is made of sheet copper, and, in the curved edge above the liquid level, holes are drilled, $^3/_{32}$ in. in diameter and with 1-in. spacing. Slots $^1/_{16}$ in. wide are cut through the upper portion of the trough from the holes to the back edge, and smoke from the titanium tetrachloride flows between the two plates in a number of streams from these slots. The trough extends across the whole width of the channel and is supported on the sides of the box by lugs and held in position by pins. Fumes from a shallow dish of ammonium hydroxide placed in the bottom of the inlet chamber will produce a denser smoke and counteract the hydrochloric acid set free by the titanium tetrachloride.

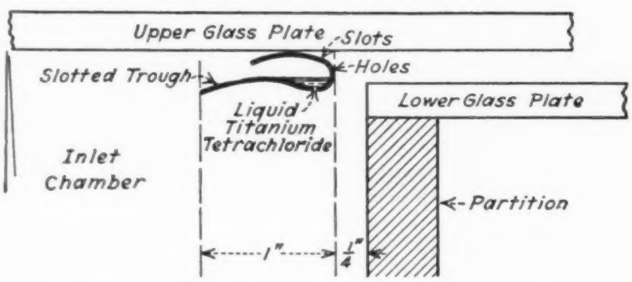


FIG. 4 SHAPE AND LOCATION ON THE SLOTTED TROUGH

RESULTS SHOWN PHOTOGRAPHICALLY

Streamlines are best observed by lighting from beneath, and satisfactory photographs have been taken by a camera, *L*, Fig. 1, with illumination from either top or bottom. A board painted with black enamel can be used instead of the lower glass plate. A vacuum-cleaner type blower will be found of ample capacity for handling a sufficient volume of air. The blower *F* has a much larger capacity than is required, and the end of the duct at *E* is left open to by-pass some of the air. A strip of rubber $^1/_8$-in. thick is cemented across the outlet end of the lower glass plate to cause a pressure drop at that point and hold the stream lines parallel to the end of the passage. Properly arranged baffles in the outlet chamber would accomplish the same purpose.

Obviously, photographs reproduced in Fig. 2 cannot show all that can be seen by the eye unless moving pictures are taken. In (*c*) and (*d*), the vortices indicated are in rapid motion. In (*f*), the portions showing dense smoke without stream lines are either without motion or have a slow reverse whirl. In (*g*), two vortices are located behind the cylinder, a definite reverse circulation starting almost at the right edge of the photograph and traveling up the center to the cylinder and around the back to the points of separation at the sides. Definite reverse whirls are also shown in (*j*), (*k*), and (*l*). With many model shapes, the flow patterns are greatly affected by change in velocity, one such effect being shown in (*a*) and (*b*). In some instances, the picture was taken of the moving stream shortly after starting, while, in others, smoke was allowed to deposit upon the glass plate to give more contrast. Such deposits are more easily removed if the glass be kept waxed.

While the results obtained by such an apparatus are largely qualitative, they have a wide practical application in addition to their usefulness in illustrating the principles of fluid flow. When some new apparatus is to be designed, through or over which fluids are to pass, a model can easily be made of the flow passage, and the flow pattern observed by the smoke lines. If the result be unsatisfactory, alterations and adjustments can be made until the best shape and proportions are obtained. Such applications are, of course, limited to cases in which two-dimensional flow will reproduce the actual conditions with sufficient accuracy.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals

FROM a variety of sources the compiler of these abstracts has assembled a cross section of the technical literature that has come to his attention during the month. Faced with the task of condensation, he has made liberal use of the authors' own words in many cases, of his own in others, and in presenting the results without benefit of quotation marks, has tried to make fairly apparent to the reader what portions may be attributed to each. Craving the indulgence of reader and author in cases where unintended distortions of the original meaning may be detected, he hopes that the sources will be sought out by those whose interest has been aroused. If as much pleasure and profit are enjoyed by readers as the compiler has had in preparing the abstracts, he will feel repaid for hopeful hours spent in the barren soil that yielded no harvest to pass on and for the task of compressing much information into a small space.

Something to Think About

SCIENCE

FOR those who like something less obvious than the matter-of-fact macroscopic phenomena of engineering, may we suggest "The Philosophy of Physics," by W. V. Houston, to be found in the April 30, 1937, issue of *Science*? A definition of philosophy which provokes much self-satisfied mirth among physicists, says Dr. Houston (and he might have included engineers), is as follows: Philosophy is the systematic misuse of a terminology especially invented for the purpose.

With this start Dr. Houston describes a series of results of physics which, he believes, may have some bearing on philosophical problems. First of these is the nature of existence on which, he says, physicists have taken a naive view that has contributed much to the successful development of physics. If one considers the statement that there exists an outside material world, the question arises, What is it outside of? An active physicist rarely stops now to consider such a question, he says, yet there is a distinct difference in the treatment accorded actions which take place within an isolated system itself and those which take place with the observer or the observer's extended senses in the form of measuring instruments, and it is just possible that this difference in treatment may be of significance beyond the regions in which it has thus far been applied.

Another subject often discussed in connection with the implications of physics, says Dr. Houston, is the problem of causality, one of the essential elements of which is that events shall have some connection in time. No body of facts can properly be called a science until these facts have been brought under a suitable system, and this must involve relations in time as well as in other ways. Hence a kind of causality must be imposed in order that there can be a science.

Using as an example two complementary but mutually exclusive aspects of quantum physics—that an electron behaves under certain circumstances as a wave and under others as having a clearly localized position as though it were a particle—Dr. Houston suggests that one might imagine problems of consciousness as having two complementary aspects. One of these might be described by such words as freedom of choice and the other in terms of physical or chemical reactions. The progress in understanding would come with the recognition that one of these descriptions does not exclude the other but that they represent entirely different aspects of the problem. This point of view, he says, may be one of the major contributions which physics has to make to philosophy.

Turning to the subject of the structure of matter, Dr. Houston shows that within the framework of the material rules adopted for describing the behavior of electrons and other basic atoms there is at present no place for questions as to the structure of the atoms involved. The number of atoms must always be an integer. This, to his mind, is a real advance in the method of dealing with atoms, as it suggests that possibly a limit is being approached in the process of subdividing matter and that further subdivision may be unnecessary.

Turning finally to the philosophy of the physicist, Dr. Houston finds this to be positivism. The central feature of positivism, he says, is its insistence upon empirical or experimental data as the only object of scientific study and its emphasis upon the descriptive feature of scientific theories.

An extreme positivist tends to be a subjectivist. He denies the existence of a material world and will admit the reality only of sensations which it is his task to classify and describe. A more reasonable positivist says that the question as to the existence of an outside world has no meaning. It is impossible to give any satisfactory definition of the term existence except as a symbol by means of which experiences can be classified.

The position of a positivist is a strong one. He formulates the rules of the game so that any question which he cannot answer can be declared to be meaningless. His point of view permits him to formulate satisfactorily such apparently irrational concepts as those of the theory of relativity and the quantum theory without talking so much about revolutions in physics as do the exponents of other philosophical systems. For these revolutions have not really been in physics but in the philosophies based on the physics. They have not disturbed the physicists so much as the philosophers.

It is possible to illustrate the difficulties which a philosophy based on the existence of a real material world may have with the theory of relativity. According to this theory, which, it must be remembered, is merely an abstract statement of observed experimental facts, the length of an object depends upon its motion relative to the physicist who measures it. When measured by different observers moving relative to it with different velocities it appears to have different lengths. What, then, is the true length of the object? The theory of relativity and the positivist philosopher say it has no true length. One measurement is as good as another for determining the length, and the business of the theory is to state the connection between the different observations.

Yet positivism is not without difficulties and has its strong

opponents, as Dr. Houston points out. In the first place, there is the usual difficulty with the position that all truth is sensation or experience, for different persons have different experiences and no two see alike. In order, then, to avoid a complete solipsism in which each philosopher is his own universe it is necessary to select in some way the experience which is more or less common to a number of observers. As soon, however, as this is done the whole question of the real difference between those sensations on which different persons can agree and those on which they differ comes up and the problem is open again. So positivism seems to face the dangers of all subjective philosophies.

Positivism has also been attacked as a philosophy of resignation and defeat, as a refusal to admit the existence of problems for which no solution can immediately be seen. Fifty years ago the positivists denied the reality of atoms. Atoms, they said, are convenient means by which to describe the results of observation, but they are by their very nature such that it will be impossible ever to isolate and observe one. It has no sense to speak of their existence. Experience since then has not justified this position. Those who have made advances in physics have been those who took the atoms seriously, who went out and found methods by which individual atoms could really be observed, and if today a positivist still maintains that atoms and electrons are only useful fictions, he must admit that they are at least as useful and necessary as anything else whose reality he would affirm.

And so Dr. Houston concludes that while positivism is a philosophy which a physicist can easily defend it is not the philosophy which really motivates him. Physicists, he contends, tend to believe that there is a real world that can be discovered, and they propose to discover it.

Registration of Engineers

COLUMBIA UNIVERSITY QUARTERLY

FOR MANY years, and increasingly since the World War, engineers have been discussing the subject of their registration by the state in which they desire to practice. On this subject, in the March, 1937, issue of the *Columbia University Quarterly*, appears the first of a series of articles under the general title "Professional Standards and Democratic Ideals," by the deans of the professional schools of that university. The first of these articles deals with engineering and is by J. W. Barker, member A.S.M.E., dean of the engineering school.

Dean Barker begins by defining licensure with a quotation from Justin Miller, of Duke University, which is as follows:

"The purpose of professional licensure is fundamentally to secure to society the benefits which come from the services of a highly skilled group and to protect society from those who are not highly skilled, yet profess to be; or from those who, being highly skilled, are nevertheless so unprincipled as to misuse their superior knowledge to the disadvantage of the people."

The movement for the registration of engineers and the requirement of license to practice engineering, continues Dean Barker, began about the time of the World War, and followed the examples set by the professions of medicine and law. Proceeding by states it has now reached a point where, in some form or other, engineers' registration laws are in force in all but a dozen states. It was obvious that the variety of these state laws would lead to a movement for some degree of uniformity and, due to the fact that an engineer practices or may practice in several states, to some system of exchange of registration between states.

It should be stated early in any discussion of this matter, says Dean Barker, that engineers are by no means unanimous in opinion as to the necessity or desirability of registration and license to practice engineering. The fact that many engineers are employed by industries and their professional work does not impinge directly on the public leads to a feeling that engineering differs materially from law, medicine, and architecture in respect to licensure. The multiplicity of types of work performed by engineers makes a uniform licensing procedure seem extremely difficult even if desirable. Many engineers feel that the licensing movement has been foisted on the profession by a militant minority to prevent competition. Many others feel that, rightly or wrongly, the licensing laws are on the statute books and only an enlightened profession working for the best interests of society can place licensing in its proper position, whatever that position may be eventually.

There are three groups concerned with the licensing procedure: The public, represented by the state board of engineering examiners; the practicing profession, represented by the various professional societies; and the engineering schools, which have the task of preparing the great majority of those entering the profession. As we approach the professional level of licensing, the qualifications of the examining boards and the rules and regulations set by them regarding the prerequisites for eligibility to take examinations as well as the nature of the examination become very important. At the truly professional level, only members of the profession are qualified to set standards and give examinations. Hence it is extremely important that membership on the state examining boards shall be confined to engineers and to those only of the highest standards and sympathetic understanding of the whole problem. It comes then to regulation *of* the profession, *by* the profession, but *for* the best interests of society.

The practicing profession is vitally concerned with how the licensing laws are administered. If the laws are used to make a tightly closed group, limited in numbers (as the tendency seems to be in medicine), then quackery without the group threatens society and some sort of criminal procedure may be necessary. There are some engineers who seem to desire such a guild concept of registration. If the laws are too loosely administered so that almost anyone can secure admission to practice (as seems to be the case in law), then incompetents from within may threaten society and the whole profession may fall in public opinion. This is almost the condition of no registration. Somewhere between is a reasonable ground.

Dean Barker then shows how professional schools are concerned, discusses the work of the Engineers' Council for Professional Development, and devotes several paragraphs to the accrediting of engineering schools being conducted by the Council. His article ends with the following:

Any eventual development of registration must be flexible enough to protect the public on the one hand and to recognize the many-sidedness of engineering activities on the other. Narrowness of viewpoint, unsocial attitudes, self-seeking, dictation or regimentation, standardization of educational procedures, all constitute potential dangers to the advancement of the engineering profession and can be minimized by an enlightened professional attitude toward all these pressing problems. In the long run, the public is going to be served by those who serve it best, be they registered engineers or not.

In correspondence the editor of these abstracts has recently received a copy of an argument in favor of registration of engineers, prepared by G. M. Butler, dean of the College of Mines and Engineering, of the University of Arizona, and transmitted by Clem A. Copeland, secretary-treasurer, of the Los Angeles Engineering Council. Mr. Copeland says that the "argument"

appeared in a local organ of the civil engineers, *ASCE*, and requests that it be republished. It says in part:

I am sure that members of any engineering registration board will testify that a large proportion of the applicants have had no education beyond the high school, and that a great many have not progressed beyond the grammar school. Many of them who seek registration as civil engineers started their engineering careers as rodmen, picked up a little mathematics, learned to manipulate the transit and level, acquired through observation and experience some knowledge of how ordinary highways and simple engineering structures are built, and thereafter they consider themselves to be full-fledged civil engineers, even if they know almost nothing about hydraulics, the principles of design, strength of materials, and many other subjects with which a real civil engineer must be familiar. Similar conditions exist in other branches of engineering, and thousands of quasi-engineers are competing or seeking an opportunity to compete with the smaller number of men who have been well trained.

It is no wonder that the public does not have a very high opinion of engineers and engineering, and that the salaries attached to engineering positions are so low since engineers are very apt to be judged by the activities of the men to whom I have just referred.

Of course, registration or licensing will not correct the situation immediately. It did not do so with the medical profession. The "grandfather clause," which must be included in all registration acts, in order that they may be constitutional, makes it necessary to register many incompetent men, but time will improve the situation, and the gradual adoption of higher standards of registration will eventually raise our calling to the status of the other professions.

It is significant that doctors, lawyers, and even ministers and teachers must be examined or in some other way demonstrate their ability before they are permitted to practice. Why should engineers be exempt? The safety and welfare of the public is certainly decidedly dependent upon the quality of their work, and there is every reason for them to wish to purge their ranks of incompetents.

The Future of Inventing

DEPARTMENT OF COMMERCE

PROCEEDINGS of the centennial celebration of the American Patent System, held in Washington on November 23, 1936, are now available in a publication of the Government Printing Office. In one of the papers presented at the celebration Robert E. Wilson discussed the subject "Looking Toward the Future of Invention."

Mr. Wilson holds that the business of inventing is inseparable from the tempo of the scientific advance, and that the only thing which can seriously retard invention is some untoward curb on the development of science. In seeking explanations of the present relatively slow increase in the number of patents Mr. Wilson advances three principal explanations: First, that the older fields of invention open to the entire population have been pretty well worked out; second, that the standard of invention in the Patent Office is certainly higher than it was; and third, that the average discovery or invention made by the scientist today is in a realm which is less likely to have actual immediate application or definite cash value within the 17-year life of a patent.

Factors which may tend to retard science and invention are also considered by Mr. Wilson. First of these discussed is the declining ratio of workers in pure and applied science. This shift in emphasis, says Mr. Wilson, has been due first to the rapidly increasing demand from industrial laboratories for better and better trained men at salaries higher than our universities and foundation laboratories can meet. During the present decade the income of endowed laboratories has, on the average, declined slightly, whereas the money spent on applied research has probably nearly doubled. It will be difficult to reverse this trend because the rate of return on endowment investments seems destined to remain very low, and the prospects for great increases in private endowments, such as marked the postwar period, seem rather gloomy in view of the many expedients which have been developed to prevent the accumulation or transmission of large stores of private capital. Furthermore, in the case of the privately endowed educational institutions the shrinkage of income is generally felt with particular emphasis in their research activities, as their educational activities naturally have first call on the available income.

As possible remedies for this situation, he says, there are four which seem worthy of consideration. In the first place, the building up of privately endowed institutions from which so many of our scientific discoveries have come should be encouraged not only by lower taxation on bequests to such institutions, but preferably by lower taxation on the entire estates of men who give a substantial proportion of their inheritance to nonprofit scientific or charitable institutions.

In the second place industrial research laboratories must in the future assume more of the responsibility for seeing that certain fields of pure science bearing upon their industry are investigated from a long-range point of view.

The third possible avenue for restoring the balance between pure and applied research, in his opinion, is by governmental aid. It is a rather sad commentary on a civilization which owes so much to science and which could gain so much from further applications of science, that, of the billions of dollars spent to relieve unemployment during the recent depression, an almost negligible amount went to the support of any sort of scientific activity, in spite of the specific recommendations to this effect by numerous scientific groups and governmental bodies.

The fourth possible method of financing an increasing amount of scientific work that Mr. Wilson mentions is from the proceeds of the occasional highly profitable commercial invention which may be made in these noncommercial laboratories.

Turning his attention to the effect of mass production and standardization Mr. Wilson says that, in spite of these hazards, machinery becomes obsolete and styles change so that neither standardization nor mass production can be a permanent bar to meritorious inventors.

A third threat to the future of invention Mr. Wilson discusses is the increasing tendency throughout the world toward regimentation and government control in every field. Even in a democracy, he says, regimentation and government control tend to have a paralyzing effect. Inventions depend largely upon the independent thought of active minds, and it is difficult to conceive of a fertile field for invention except in an environment which encourages individual independence to the greatest possible degree. The discouraging effect of regimentation might not be so apparent in the first generation, but the effect of a national goose-step would certainly show up in the second. Possibly the most serious danger confronting the future of invention throughout the world is this increasing tendency toward regimentation and political domination of all activities.

Mr. Wilson makes an interesting speculation as to a factor

which may in the long run seriously hamper the rate of extension of science and invention. This is the rapidly increasing length of time required to prepare the average individual to do effective work on the frontiers of science. In other words, there is a rapidly increasing amount of prior information which a scientist must master before he is competent to make additional advances. If this process continues, men will pass their prime in so far as their inventive faculties are concerned before they reach the level where they are competent to begin pioneering work.

It is Mr. Wilson's opinion that this situation can be improved by more efficient methods of education, particularly in the elementary and high schools, at least for individuals who show real promise of scientific ability. Our present public-school system is very wasteful of the time of the small percentage of students who are really brilliant and we must find some method of discovering this potential brilliance and giving it more expeditious training if we are long to maintain the present pace of scientific advance.

Management's Responsibility

PHILADELPHIA SECTION, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

SPEAKING at a meeting of the Philadelphia Section of The American Society of Mechanical Engineers, R. L. Sackett, vice-president of the Society and dean of engineering, Pennsylvania State College, drew the attention of his hearers to the responsibility of management for social security.

Following a brief recital of some of the contributions which industry has made to social welfare and calling attention to the pioneer work in management done by Henry M. Towne and Frederick Winslow Taylor, Dean Sackett listed some of the achievements of management as follows: Fair wage systems; time and motion analysis to equalize wages and reduce physical effort; study of welfare, sanitation, lighting, and heating of factories; introduction of the physical examination, medical care, and hospitalization; workmen's compensation, pensions, and insurance plans; and the development of personnel systems.

New disturbances of industrial relations, he said, made it necessary to explore the rights and duties of men and management from an unbiased angle. It was the duty of management, he asserted, to protect the property of investors against the unscrupulous and the destructive; to protect labor against the radicals that are its worse enemies; to make reputable goods and provide honest services; to advertise the truth and protect the consumer against exploitation; to manage equitably the funds invested in the business in the interests of labor, the investor, and the consumer; and to lead in raising and maintaining the standard of living.

Social security, he maintained, was entirely dependent on the production of wealth. It is the duty of management to protect industry against injustice. Industrial peace is necessary to the production of wealth. The chaotic state of emotional anarchy now retarding industrial recovery, he said, was a disease caused by a warfare for power or a chronic distrust on the part of labor organizations and management.

America needs special wisdom, courage, and understanding if it is to deal wisely and justly with itself in this crisis, he concluded. The restoration of legal and spiritual government is in the hands of employees, employers, and the public. Peace cannot be proclaimed by legislation. It ultimately depends on the character and intelligence of management, labor, and the people.

Alignment Charts

OHIO STATE UNIVERSITY

FROM the Engineering Experiment Station of the Ohio State University comes circular No. 34, by Paul N. Lehoczky, entitled, Alignment Charts: Their Construction and Use.

This 62-page circular covers but a small portion of the useful and extensive subject generally known as nomography and, as its title states, is concerned solely with charts of the alignment type.

This type of chart, which is used for the graphical computation of specific formulas, consists of a set of lines on which scales are laid off. These lines are so arranged with respect to one another that by means of a straightedge connecting known values of factors represented on any two of the scales, for example, the value of a third factor can be read at the intersection of the straightedge and the scale representing that third factor.

Many engineering formulas lend themselves to solution by the alignment-chart method, and the circular referred to is a guide to those wishing to acquaint themselves with this useful calculating tool. As a convenience in laying out the scales necessary in constructing alignment charts the circular contains a ruled chart from which arithmetic and logarithmic scales of any length from 0 to about 10 in. can be taken.

Photography in Research

JOURNAL OF APPLIED PHYSICS

AMONG those who have adapted photography to the uses of the research worker in making measurements and investigating phenomena taking place at high speed is H. E. Edgerton, of the Massachusetts Institute of Technology who, in the January, 1937, issue of the *Journal of Applied Physics*, collaborates with J. K. Germeshausen and H. E. Grier in a paper entitled "High Speed Photographic Methods of Measurement."

The paper discusses methods of taking high-speed photographs by means of a violent discharge of an electrical condenser through a gas-filled tube or gap. A device for producing a single flash of light is first described. This device is portable, requires less than 100 watts from a 110-volt 60-cycle outlet, the flashes last about 10^{-5} sec, and are bright enough to expose adequately common grades of film in that short interval of time, with ordinary camera equipment. The flash is produced in a gap in air by the violent discharge of a 3-microfarad condenser that has been charged to about 15,000 volts. Approximately 10 sec are required to charge the condenser before the flash. Control of the instant of the flash is obtained by applying a high potential to a third electrode placed near the gap. The main-gap electrodes and the condenser potential must be adjusted until flashover is imminent when the condenser is fully charged. The application of a high-voltage impulse to the third electrode causes the main gap to break down at the desired instant. The paper contains several examples of photographs taken by this method.

An electrical arrangement capable of taking photographs with exposures much shorter than those already mentioned is also described. With it photographs may be taken by reflected light at f:8 in less than two microseconds. The gap consists of a 2-in. length of Pyrex tubing 6 cm inside diameter filled

with argon at atmospheric pressure. Wiring diagrams of both types of apparatus are given.

For studying mechanical problems a high-speed motion-picture apparatus of the stroboscopic-light type is described. The camera is capable of taking 1200 pictures a second on a standard 35-mm film, and these may be slowed down during projection so that the eye can follow the motions and distortions photographed. A schematic diagram of a continuously moving film camera and a wiring diagram of a source of stroboscopic light are included. High-pressure argon lamps have proved to be more satisfactory for producing stroboscopic light than mercury lamps, principally because of the lack of temperature effects. The principal limitation of the stroboscopic-light type of high-speed motion camera is its inability to record self-luminous subjects.

By using a moving optical system whereby the image cast by the lens is held stationary with respect to a continuously moving film it is possible to take photographs at high rates of speed, due to the elimination of the intermittent mechanism of the common motion-picture camera. Three types of moving optical systems have been developed, employing, respectively, rotating lenses, rotating mirrors, and rotating prisms.

The authors state that the art of high-speed motion-picture photography, although relatively new and still undergoing development, is sufficiently advanced to have been adapted to many industrial applications.

Electrostatic Precipitator

ELECTRICAL ENGINEERING

ELECTROSTATIC precipitation of very fine particles of dust from gases has engaged the attention of engineers for many years. The most serious factors limiting its use, according to G. W. Penney in an article entitled "A New Electrostatic Precipitator" in the January, 1937, issue of *Electrical Engineering* are: (1) Direct-current voltages of from 30,000 to 100,000 and appreciable current are required; (2) the space required is large both for the precipitator as well as the high-voltage transformer and rectifier; (3) the corona discharge of the conventional precipitator generates so much ozone that the cleaned air, although free of dust, is too irritating to the nose and throat to be used for ventilation; and (4) first cost and maintenance are both high as compared to other types of cleaning equipment.

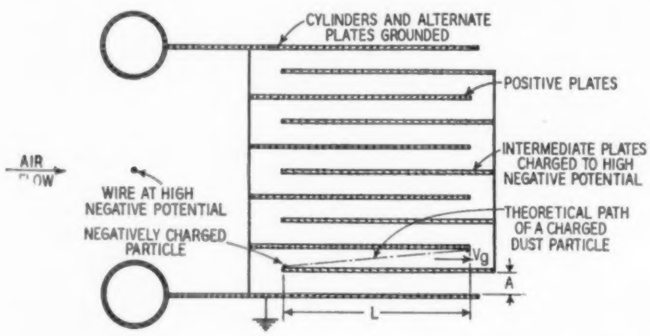


FIG. 1 CROSS SECTION OF THE IONIZING UNIT AND PARALLEL DUST-COLLECTING PLATES OF AN ELECTROSTATIC PRECIPITATOR, SHOWING THE PATH OF A DUST PARTICLE

The conventional process of electrostatic precipitation, says Mr. Penney, uses a wire or system of points at high potential so that a corona discharge carries the dust to the opposite electrode. An effect known as "electrostatic wind," a movement of air away from the discharge points, that carries dust to the collecting electrode, is set up, but this requires the displacement of air away from the collecting electrode with the result of introducing inefficiency into the method. In the device described an attempt is made to ignore the electrostatic wind and to develop the most efficient means for charging the particles and attracting them out of the air. It has been found possible, says Mr. Penney, to ionize the particles first and then separate them from the gas in the electrostatic field between parallel charged plates.

Fig. 1 shows schematically the cross section of an electrostatic precipitator with ionizing unit and parallel dust-collecting plates. Fig. 2 is from a photograph of a precipitator developed for use with a spray booth in a pottery plant. Referring to Fig. 2, the high-voltage power-supply unit consisting of transformer, rectifier tubes, and condensers, is mounted in the case at the left. The ionizing units are mounted in the lower part of the case and the plate assemblies are above it. The ionizing unit consists of parallel grounded cylinders with wires carried

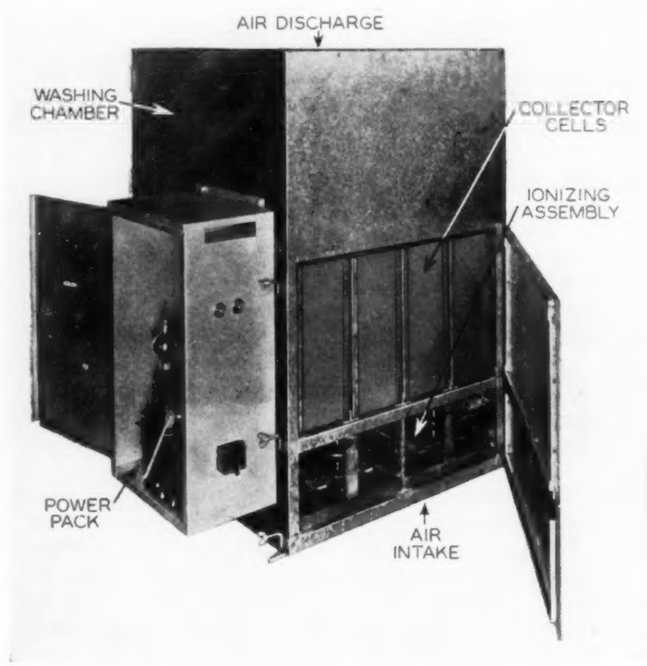


FIG. 2 AN ELECTROSTATIC PRECIPITATOR DEVELOPED FOR USE WITH A SPRAY BOOTH IN A POTTERY PLANT

on insulated supports between the cylinders. The wires are connected to the high-potential power source giving 12 to 14 kilovolts, direct current. Some dust collects on the grounded cylinders of the ionizing unit, but most of it is deposited in the dust-collection plate assemblies.

The type of precipitator described by Mr. Penney is particularly adapted to removing light concentrations of fine dust. Some of the principal fields of application are: (1) Removal of industrial dusts that constitute a hazard to health; (2) air cleaning to protect delicate apparatus or processes; (3) air cleaning in homes and offices, in cities where soft coal is burned, to reduce cleaning of walls and furnishings; (4) air cleaning for relief of hay-fever and asthma sufferers; and (5) air cleaning in stores to reduce damage to merchandise.

The "Combined" Steam Engine

THE INSTITUTE OF MARINE ENGINEERS

FOR 50 YEARS, says W. A. White in a paper before The Institute of Marine Engineers entitled "The White Combined Steam Engine," the reciprocating engine had been considered desirable for cargo-carrying vessels, but with the coming of the recent slump in shipping it was found necessary to reduce steam consumption yet retain the advantages of multicylinder propulsion units. This the author claims to have accomplished with the White combined steam engine, described in the paper.

The propulsion unit described consists of a compound reciprocating steam engine and exhaust-pressure steam turbine which drive the propeller through reduction gearing. Advantage of high steam temperature is obtained by means of superheaters in the boilers, and by the use of reheaters between the high- and low-pressure cylinders of the reciprocating engine, and the low-pressure cylinder and the exhaust turbine.

Having worked out a suitable design of compound steam engine the author fitted a single-screw 8000-ton deadweight steamer originally driven by a compound steam turbine with a twin compound steam engine, replacing the high-pressure turbine of the original installation. The low-pressure turbine and its condenser were retained. The engine was carefully designed to minimize the effects of unbalanced inertia forces and was fitted with a flywheel mounted between the engine and the gears. The torque characteristics of the installation showed that the oscillating system comprising the engine masses and the pinion shaft was tuned to a frequency of 420 vibrations per minute with critical speeds at 210, 140, and 100 rpm; and as the normal running speed was 280–300 rpm it was therefore located in the quiet region between the first- and second-order critical speeds. The boilers were equipped with superheaters to raise the temperature to 600 F.

In the reciprocating engine the reheating is effected by extracting heat from the superheated steam in its passage from the engine stop valve to the high-pressure valve chest, while the turbine steam is heated by superheated steam going to the auxiliaries. A separator was placed between the engine and the turbine. While the ship was in drydock undergoing alterations a solid-bronze propeller was substituted for the original built-up propeller, and the rudder post was streamlined.

In comparing performance before and after alterations, making a run between Buenos Aires and Liverpool in one case and between Montevideo and Sharpness in the other, it was found that the oil per shaft horsepower per hour was 1.165 lb before conversion as compared with 0.665 lb after, representing a saving of 43 per cent. As one boiler had been removed and extra cargo space provided, the deadweight cargoes in the two cases were 7001 and 7705 tons, respectively.

The ship in question has steamed 160,000 miles since the new machinery was installed in 1934, and up to the present, it is said, repairs to the engine have been nil. The engines were recently opened for examination. The gears revealed no signs of wear, and cylinders, valve liners, and pistons were in excellent condition. Main bearings and the bottom ends of the reciprocator showed negligible wear.

It is said that if desired the reciprocating engine can be disconnected from the turbine and operated alone, developing about 65 per cent of full power. Reversal from full ahead to full astern can be effected in 17 sec without increasing the normal loading of the gears, and in emergency the time can be reduced to 12 sec without exceeding the overload margin. It is said that the inertia effect of the turbine and gears prevents any excessive increase in propeller revolutions when the vessel is pitching, with the result that a higher average speed can be maintained in bad weather.

Magnetic Molding Machine

ENGINEERING

FOR RAPID molding of small parts a British firm has developed a line of electromagnetic molding machines briefly described in the Jan. 8, 1937, issue of *Engineering*. The power required for the squeezing operation is obtained from a solenoid, or solenoids, mounted in the base of the machine and energized by direct current.

The main casting of the machine forms the outer casing of the solenoid. The upper part of the core is stationary, being fixed to the main casting, while the lower part, which is movable, is attached by a rod of nonmagnetic material to the presser table of the machine. When the solenoid is energized by pressing a button the movable part of the core is drawn up, giving an upward movement to the presser table on which the pattern plate and flask are mounted. This upward movement brings the sand with which the flask has been filled into contact with a swing-in presser head, adjustable to suit the depth of the flask.

In the upward stroke a stripping plate, on which the joint edges of the flask rest, moves up also. The return stroke is by gravity and is controlled by a dashpot, to the movable part of which the core is connected. The machine table, pattern plate, stripping frame, and squeezed mold are allowed to descend sufficiently to enable the presser head to swing to one side, after which the descent of the stripper frame is arrested automatically by clutches. The finished mold may then be lifted off while the machine table and pattern descend to the end of the stroke. The stripping frame is then returned to the working position by means of a trip lever. The operation of the machine, after the button has been depressed, is entirely automatic.

The main advantages claimed for the machine are said to be simplicity in action and accuracy in construction. Actual time elapsed between pressing of the button and finished mold ready for removal is said to be from 8 to 10 sec. The pressure exerted is 35 lb per sq in.

An Isothermal Chamber

THE INSTITUTION OF ELECTRICAL ENGINEERS

IN A paper read on May 5, 1937, before The Institution of Electrical Engineers, L. B. Turner describes an isothermal chamber that, it is claimed, can be held constant to one thousandth of a degree centigrade. In introducing the description of the apparatus designed by him the author offers a brief discussion of thermostats, and then confines his attention to electrically operated devices in which the temperature-sensitive element enters into a bridge configuration. Departure of the temperature from the assigned working value by throwing the bridge out of balance effects a corrective change in heat supply.

A skeleton diagram of the whole apparatus is shown in Fig. 3, and is largely self-explanatory. The isothermal chamber *O* is an aluminum-alloy pot, with the upper end removable to form a lid. Two resistors marked "58 ohms" lie in a helical

groove cut in its external surface: one is of platinum, with temperature coefficient of resistance 0.00327_0 per deg C and the other is of silver-platinum alloy (2:1) of temperature coefficient 0.00024_6. The resistances are almost equal at the working temperature of the chamber, which is about 50 C; but their ratio changes 3.03 parts in a million per thousandth of a degree centigrade change of chamber temperature. Together they are

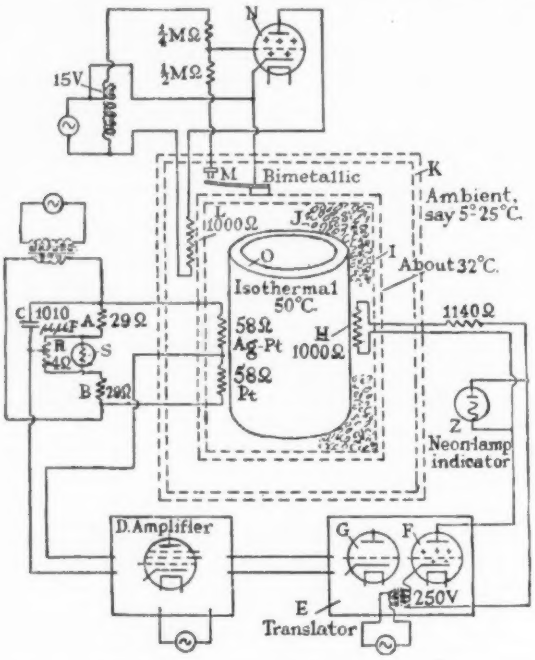


FIG. 3 SKELETON DIAGRAM OF ISOTHERMAL CHAMBER

(~ = Mains, 200 volts, 50 cycles per sec
S = Compensation lamp, tungsten, rated 6 volts × 0.06 amp.)

the temperature-sensitive element of the thermostat, the "master coil;" and they form two arms of the Wheatstone bridge, whose other two arms consist mainly of the two resistors A, B, marked "29 ohms." These two fixed resistors are of constantan, No. 28 S.W.G., double-cotton-covered, wound, interspaced, on a copper tube of 1 in. diameter. Their resistances are nearly equal, and retain a constant ratio despite changes in their common temperature. The tube on which they are wound is mounted vertically in the open air. All resistors are constructed to be as noninductive as possible; and the bridge is balanced (for the fundamental frequency) by the condenser C marked "1010 $\mu\mu F$."

Out-of-balance potential difference from the bridge is led, via the valve amplifier D, to the translator E, which comprises a gas-filled output valve F controlled by an input valve G. The output from the translator is alternately nearly nothing (when the chamber is too hot), or the half sine waves of current from the gas-filled valve (when the chamber is too cold). The current passes through the 1000-ohm slave coil H, which is wound noninductively around the chamber and the master coils.

The chamber is housed in a cylindrical canister I of 7 in. diameter, with an insulating packing J about $1^1/_4$ in. thick of glass silk supplemented by celotex. The presence of this jacket divides the heat emission from the chamber by 4 or 5. The canister is fixed in a wood case K, and has a heating coil L wound noninductively upon it. Intermittent heating of this coil, under the control of a simple bimetallic-strip contactor M and a gas-filled valve N, holds the temperature of the canister at about $32 \pm {}^1/_2$ C whatever the ambient temperature between the limits 5 C and 25 C. The gas-filled valve N ignites only when the bimetallic contact is closed.

Extreme-Pressure Lubricants

PHILADELPHIA SECTION, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

WITH increase of the amount of power transmitted and decrease, relatively, of gear sizes in automobiles, engineers have been put to it to provide suitable lubrication for the pressures involved and have conducted many researches on the subject, as pointed out by J. G. Geniesse, of the Atlantic Refining Co., in a paper presented in March, 1937, to the Philadelphia Section of The American Society of Mechanical Engineers.

Conventional types of lubricating oils, said Mr. Geniesse, have proved ineffectual with certain automobiles. In researches on the subject it was discovered that viscosity proved to be an unimportant factor in controlling the load-carrying capacity of a lubricant, while the addition of certain chemicals—sulphur, chlorine, phosphates, and lead soaps—increased the load-carrying capacity at least tenfold.

Most of the extreme-pressure lubricants developed to date contain ingredients which form antiweld agents or fluxes only when required and only at the surface in distress. It is evident, then, that the activity of the chemical must be sufficient to make it available at a temperature somewhat below that required for welding. On the other hand, it must not be too active or corrosion may take place.

This method of lubrication is far more satisfactory than one might expect, since excessive loading is for intervals and over only exceedingly small surface areas. Thus chemical activity for surface protection takes place infrequently.

Little is known about the chemical nature of the phenomenon of extreme-pressure lubrication. It is believed, however, that there is a reaction between the metal surface and the active ingredient of the lubricant. For instance, if the lubricant contains a sulphur compound of the right type it is the opinion of many technicians that the sulphur splits away from the lubricating-oil component and then reacts with the iron of the bearing surface to form iron chloride, which in turn acts as a flux and lubricant.

In addition to high load-carrying capacity the extreme-pressure lubricant must have the following properties: Low abrasive index, low free chemical activity, high thermal stability, and high fluidity at low temperatures.

The free chemical activity must be low in order to avoid corrosion. This requires rather careful control, since some activity is required in order to make the lubricant effective.

High thermal stability is required in order that the lubricant may retain its activity and fluidity over long periods of time at rear-axle temperatures. Long-time high-speed tests in gears either in the car or in the laboratory are most effective for determining the life of the lubricant, although some progress has been made toward developing a laboratory test that costs little and consumes less than one week's time.

The application of extreme-pressure lubricants to mechanisms other than automotive gears has been increasing, although, for obvious reasons, at a much slower pace. Before specifying an extreme-pressure lubricant for a given job it is necessary to consider the kind of metal used for the bearing surfaces, the loads, speeds, and the temperatures normally encountered. For instance, one that is satisfactory for steel on steel may be of no value for bronze or babbitt. It is also necessary to consider

the other metals the lubricants may reach and the oxidation conditions that may prevail. In spite of these varying conditions of operation, it is definitely possible to increase machine life by using extreme-pressure lubricants.

Improving Lubricating Oil

OIL AND GAS JOURNAL

A BRIEF description of how the quality of lubricating oils is said to be improved by the addition of an electrically treated concentrate known under the commercial name "Elektrion R" is to be found in the March 25, 1937, issue of the *Oil and Gas Journal*. Elektrion R is produced in Belgium by the Société des Huiles de Cavel and Roegiers by modifying the molecular structure of lubricating-oil particles by passing the oil between electrodes maintained under a high electrical potential.

When the additive so produced is blended with lubricants so that the blend represents 5 to 15 per cent of the total, the finished motor oil provides an increase in the viscosity of the lubricant and in addition improves its viscosity index. The additive also acts as an antisludging agent, improves oiliness, and lowers the pour point.

The Gyroplane

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

FROM the *Journées Techniques Internationales de l'Aeronautique* for Nov. 23–27, 1936, the National Advisory Committee for Aeronautics has made available a paper entitled "The Gyroplane—Its Principles and Its Possibilities," by Louis Breguet, translated by J. Vanièr, compiler of the "Dictionary of Aeronautical Terms" published some years ago by The American Society of Mechanical Engineers.

The gyroplane, says, the author, belongs to the helicopter family and, as the name implies, has wings in the form of propellers. This type of aircraft has large propellers, with substantially vertical axes, set in motion by an engine, and the reaction of the air on the revolving blades produces an upward lift in excess of the weight of the entire apparatus. As a result, the machine can ascend in the air without forward speed. The gyroplane, says M. Breguet, is a helicopter designed to move diagonally in the air at a speed as high as possible. It has no propulsive propeller, since its rotating wings driven by the engine are sufficient both for propulsion and sustentation.

To distinguish the gyroplane from the autogiro the author points out that on the autogiro the rotating wings are not controlled by the engine but are mounted free on a central shaft. The engine drive, as in the airplane, one or more regular propellers. The relative wind, due to the translation provided by these propellers, sets the blades in autorotation.

The gyroplane, he continues, quite apart from the faculty of vertical flight, offers additional advantages, particularly in regard to the overall efficiency which is enhanced by the absence of the propulsive propeller. Propulsion and sustentation by the same rotating-wing system allows much higher forward speeds; and it has been proved that the propulsive efficiency is then practically equal to unity. M. Breguet's first gyroplane with flexible wings was built in 1905–1906 and made its first free flight in 1907 with one man aboard. Other machines have since been built.

Following a description of early investigations, the author enters into a discussion of the aerodynamics of the gyroplane. He finally proposes the gyroplane of the future, a sketch of which appears in Fig. 4. This represents a three-engine amphibian with retractable skids forming ballonets and with a hull. The total weight is 35,273 lb, the propeller diameter 82.02 ft, and the blade area 365.97 sq ft. The maximum power output at 9843 ft is 3600 hp, and the speeds at this altitude are, respectively, 311 mph using 2900 hp, 249 mph with 2400 hp, and 155 mph with 200 hp. The power input while hovering at this same altitude is 2650 hp.

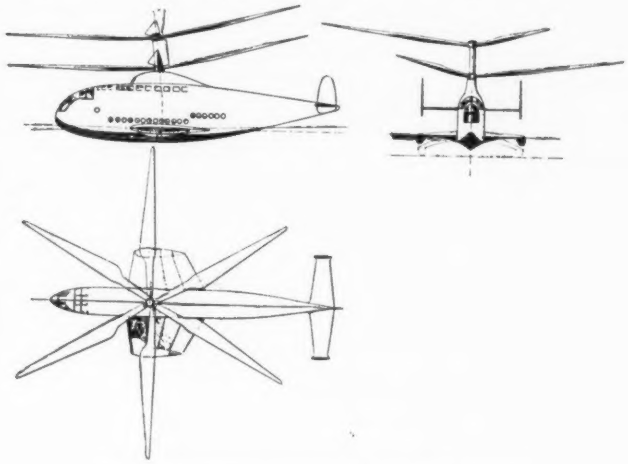


FIG. 4 PROPOSED GYROPLANE OF THE FUTURE

In addition to the advantages of speed and lightness claimed for the gyroplane, M. Breguet lists the following:

1 Practically no response to aerial eddies.

2 Absence of stalling and the facility, in case of engine trouble, of descending with low wing loading.

3 Possibility of joining several engines to the central shaft in a comfortable engine compartment affording uninterrupted inspection and accessibility.

4 Possibility of vertical ascent from ground or water.

5 Small overall dimensions for storage since the articulated blades are easily folded.

6 Military qualities, since the gyroplane can take observations where absence of motion is desired.

7 Uses in naval aviation, where gyroplanes can be used without catapults.

Cooling Finned Cylinders

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

IN ATTEMPTS to increase the rate of heat flow from aircraft-engine cylinders cooled by air, designers have resorted to the use of closely spaced circumferential fins that enormously multiply the metal-cooling area exposed to the air stream. Obviously, there exist optimum conditions in respect to the size and spacing of these fins that bear on the question of maximum heat flow from the cylinder and energy expended in forcing air through the fins.

These factors have been investigated by Oscar W. Schey and Herman H. Ellerbrock, Jr., who made use of electrically heated finned steel cylinders enclosed in a jacket and subjected to a stream of air from a blower. The experiments and results are described in report No. 587, of the National Advisory Committee for Aeronautics, entitled "Blower Cooling of Finned Cylinders," from which the following has been abstracted.

The effect of the air conditions and fin dimensions on the average surface-heat-transfer coefficient q and the power required to force the air around the cylinders were determined. Tests were conducted at air velocities between the fins from 10 to 130 mph and at specific weights of the air varying from 0.046 to 0.074 lb per cu ft. The fin dimensions of the cylinders covered a range of fin pitches from 0.057 to 0.25 in., average fin thicknesses from 0.035 to 0.04 in., and fin widths (radially) from 0.67 to 1.22 in.

The average surface-heat-transfer coefficient q, based on the temperature difference between the cylinder and the inlet air, varied as the 0.667 power of the weight velocity of the cooling air for cylinders with fin spaces from 0.077 to 0.21 in. Below 0.077 in. the exponent of the curves increased for each successive decrease in space.

The average surface-heat-transfer coefficient q, based on the temperature difference between the cylinder and the inlet air, was independent of fin width for a range of fin widths from 0.67 to 1.22 in. and decreased as the space between the fins decreased. Below approximately 0.048 in. the decrease of q with fin space was very rapid.

The average surface-heat-transfer coefficient q, based on the difference between the cylinder temperature and the average air temperature, remained constant for a given weight velocity of the air, for fin spaces from 0.048 to 0.131 in.; below approximately 0.048 in. q decreased and above 0.131 in. q increased.

The power required to force the air around the cylinder varied directly as the 2.69 power of the weight velocity for a constant specific weight for a constant weight velocity of the cooling air.

For a given power expended in cooling, the heat dissipated from the cylinder could be increased by decreasing the space between the fins to approximately 0.045 in. for a cylinder with fins 1.22 in. wide. Below 0.045-in. heat dissipated decreased.

Lubricating Aircraft Engines

ENGINEERING

IN OPERATING aircraft engines the time which elapses between the starting up of the cold engine and that at which the lubricating system is functioning normally is a drawback. A high-initial-oil-pressure system has been evolved by the British builders of Bristol engines, according to *Engineering* for January 29, 1937, which makes it possible for the engine to develop its full power with perfect safety as soon as it is started. It is said that the system has been subjected to laboratory and flight tests for a period of five years.

With the system described oil is delivered to the engine from a pressure pump and enters through the rear end of the crankshaft. A main relief valve in connection with the delivery pipe is set to maintain a pressure of 80 lb per sq in. with oil at 70 C. Oil by-passed through the relief valve is returned to the oil tank under its own pressure. A restrictor fitted in the return line from the relief valve to the tank permits the oil to circulate at a reasonable pressure. When, however, the oil is cold the restrictor will produce a higher pressure in the bypass pipe, owing to increase in viscosity, and also because a greater amount of oil is passing through the relief valve. As the oil pressure in the delivery pipe to the crankshaft also increases, this relief valve is opened and at the same time a so-called sprayer valve between the relief valve and the crankcase, located on the engine side of the restrictor, will also open, with the result that oil is sprayed directly on the crankpin bearing. As the oil warms up both its viscosity and the amount passing the relief valve decrease, the pressure on the restrictor is decreased, the sprayer valve closes, and the oil supply to the sprayer is cut off.

"Common Law" of Industrial Relations

(*Continued from page 436*)

Labor Board and the National Labor Relations Board, the experience upon which the Wagner Act[2] rests, as follows:

1 It was unlawful for an employer to impose on his workers any scheme of collective bargaining against their will.

2 Workers were lawfully free to choose between representation by trade unions or company unions.

3 The government was to settle representation controversies by elections or by other means of ascertainment.

4 The labor boards were to define appropriate units for collective bargaining in all cases where questions of this nature were raised.

5 The labor organization which commanded a majority of the voters among the employees engaged within the collective-bargaining unit was entitled to certification as the employees' representative.

6 The employer was obliged to "recognize" representative labor organizations; that is, to negotiate with them in good faith.

7 Employers and employee representatives alike were bound to "exert every reasonable effort" to make and maintain collective agreements.

8 No employer was to lay off, discharge, or otherwise discipline his workers for their union membership or activities.

[2] These principles have been incorporated into the Wagner Act. That act makes it an unfair labor practice for an employer: (1) "To interfere with, restrain, or coerce employees in the exercise of their rights" to self-organization and to collective bargaining. (2) "To dominate or interfere with the formation or administration of any labor organization or contribute financial or other support to it." (Contributing financial or other support was used as a criterion of interference by the National Labor Relations Board, the "second" NRA board.) (3) "Discrimination in regard to hire or tenure of employment" or any condition of employment (with a proviso protecting the closed shop). (4) To discriminate against an employee for giving testimony under the Wagner Act, and (5) "To refuse to bargain collectively" (the duty to bargain collectively on the part of the employer is, in reality, implied in the right of workers to so bargain). The Wagner Act also gives labor the specific rights of self-organization and collective bargaining.

Effective Use of Metal-Cutting Tools

(*Continued from page 414*)

conditions, and chips came off a dark straw color. As a matter of interest, conditions were calculated by the formulas previously mentioned. Chip proportions in the first instance would have indicated serious difficulty from chatter under the first set of conditions, if it had occurred on a lathe, while, under the second set of conditions, little or no chatter was to be expected. Cutting speed for the final conditions should have been 54 fpm, as against the 51.5 fpm actually employed. Calculation of power required indicated 25.2 hp at the cutter, or 42 hp input to the machine. As the milling machine taking the cut was equipped with a 40-hp motor, the cut was as heavy as could reasonably be expected.

The foregoing examples and analyses are an exceedingly brief résumé of the work accomplished by the committee. Its final report will comprise a handbook containing several hundred pages of tables that cover practically the entire field of ferrous-metal machining with single-nose cutting tools. In addition, it will present data covering selection of tool material, heat-treatment, tool grinding, use of cutting fluids, the cause and prevention of chatter, and a résumé of the mathematical studies involved in the development of the information presented.

LETTERS AND COMMENT

Brief Articles of Current Interest, Discussion of Papers in Previous Issues

The Steam Turbine in the United States

To the Editor:

Although references to Dr. De Laval occur in the papers[1] presented this evening, I believe that he should receive greater credit, as he was a pioneer in not only the invention and practical perfection of the steam turbine but also in the application of ultrahigh steam pressures and temperatures and the development of high pitch line speed helical gears for use with turbines. As was pointed out in a biography of Sir Charles Parsons,[2] Dr. De Laval preceded Parsons by about one year in the invention of the steam turbine. In other words, he patented and built his first commercially practical steam turbine in 1883, and not in 1888, as has been stated by Messrs. Keller and Hodgkinson in their paper.

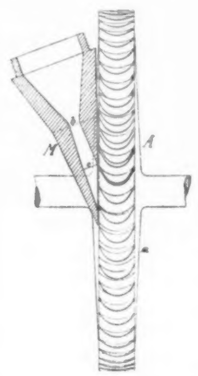


FIG. 1 DIVERGING NOZZLE FOR HIGH EXPANSION RATIO

Many important elements of the impulse-type steam turbine, which are now in universal use, must be credited to De Laval, one of the most important being the diverging steam nozzle, which is shown in Fig. 1. This was invented in 1888 and develops a corresponding steam velocity for any pressure drop, without which high efficiency would be impossible. It is also used in many reaction turbines where the first stage has an impulse wheel. The revolutionary character of this invention is illustrated by the fact that, although the American patent application was filed in 1889, the Patent Office examiners, for four years, refused to believe that the scheme would work at all, and, not until a De Laval single-stage turbine fitted with diverging nozzles was exhibited in operation at the World's Fair at Chicago in 1893 (see Fig. 2), were the claims allowed and the patent allowed to issue in 1894. I believe that Dr. De Laval was the first to conceive the idea of, and to develop formulas for, the flexible shaft, which was introduced in 1884 and is extensively used in modern impulse turbines of large capacities to reduce the shaft diameter and, as a consequence, to reduce materially the leakage that occurs from stage to stage.

In 1889, De Laval developed diagrams for, and designed, the first velocity-stage turbine, which was introduced commercially in 1893. The principle of velocity staging was an extremely important contribution to the art and is widely used today, even in reaction turbines, where the first stage often is of the velocity compounded type. According to Messrs. Keller and Hodgkinson, this design was adopted by Westinghouse in 1907.

De Laval originated and developed high pitch line speed helical gears about fifty years ago. This also must be considered as an outstanding contribution to the progress of the steam turbine, particularly in the field of ship propulsion.

In the year 1892, De Laval designed and built the 15-hp geared marine turbine with reversing wheel which is illustrated in Fig. 3, while in 1907 he designed a triple-casing geared turbine.

The first steam turbines to be used in American central stations were two 300-hp single-stage geared units built by the French De Laval company, which were installed, one in the 12th Street Station and one in the 39th Street Station of the New York Edison Company,

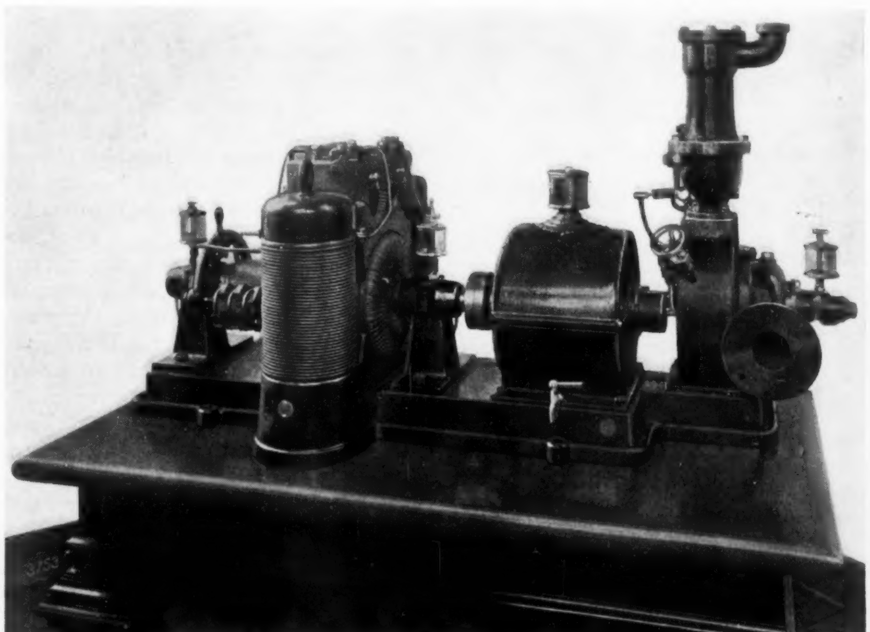


FIG. 2 DE LAVAL GEARED TURBINE GENERATING SET EXHIBITED IN OPERATION AT CHICAGO WORLD'S FAIR IN 1893

[1] "The Steam Turbine in the United States. I—Developments by the Westinghouse Machine Company," by E. E. Keller and F. Hodgkinson, Mechanical Engineering, vol. 58, 1936, pp. 683–696; "II—Early Allis-Chalmers Steam Turbines," by A. G. Christie, Mechanical Engineering, vol. 59, 1937, pp. 71–82; and "III—Developments by the General Electric Company," by E. L. Robinson, Mechanical Engineering, vol. 59, 1937, pp. 239–256.

[2] "Sir Charles Algernon Parsons," Mechanical Engineering, vol. 53, 1931, pp. 317–318.

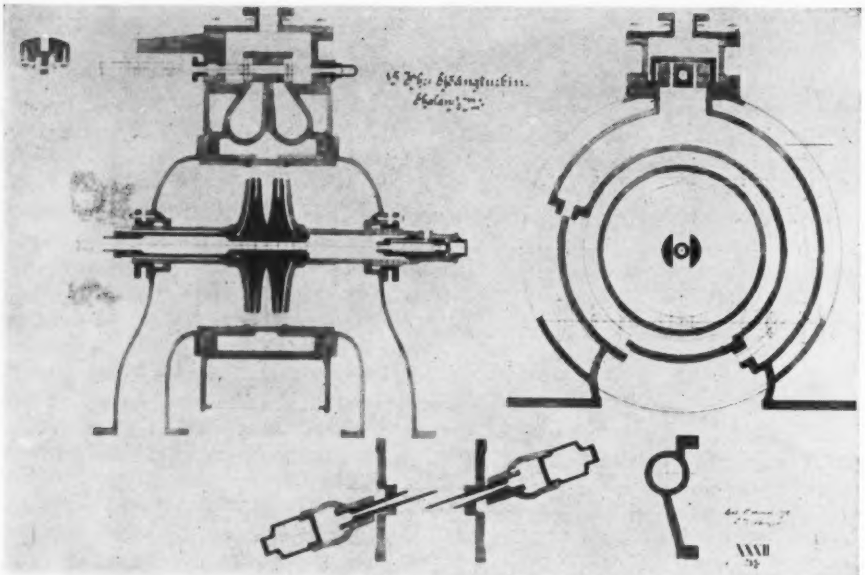


FIG. 3 GEARED MARINE TURBINE WITH REVERSING WHEEL
(In this turbine, which was built by De Laval in 1892, the wheels were shielded to reduce skin friction.)

in 1896. The first De Laval turbine to be built in America was completed at the works of the De Laval Steam Turbine Company, Trenton, N. J., in 1901.

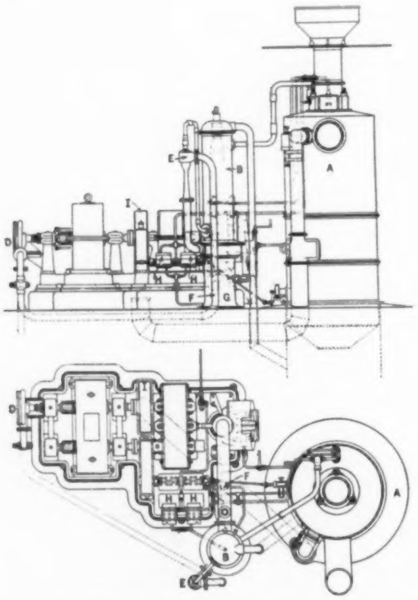


FIG. 4 COMBINED BOILER, TURBINE, AND CONDENSER UNIT THAT WAS INSTALLED AT THE STOCKHOLM UNIVERSAL EXPOSITION IN 1897
(Six of these units, two of 50 hp and four of 100 hp, supplied all the electrical energy required. This unit was supplied with steam at a pressure of 2800 lb and a temperature of 750 F. The different parts of the unit are *A*, boiler; *B*, condenser; *C*, turbine; *D*, circulating pump; *E*, air ejector; *F*, condensate pump; *G*, feedwater tank; *H*, feed pump; and *I*, forced-draft blower.)

An indication of De Laval's engineering foresight and of his highly successful adaptation of scientific principles when making radical departures from existing practice may be had from his work with high steam pressures and temperatures. At the 1897 Universal Exposition in Stockholm, or nearly 40 years ago, De Laval turbines receiving steam at 1400 to 2800 lb pressure and a temperature of 750 F were in operation. Each unit (see Fig. 4) included boiler, furnace, draft fan, and feed pump, as well as condenser, condenser auxiliaries, and automatic control. Without doubt, these were the first turbines to operate under steam conditions that only in recent years, have been adopted or approached by stationary power plants. Six of these units, two of 50 hp and four of 100 hp supplied all electrical energy required by the Exposition. Two similar units, of the 100-hp size, were placed in operation on March 9, 1897, at the De Laval Works at Järla and supplied power for the plant during the following year. The spiral-tube boilers, which were fired with soft coal or anthracite and equipped with forced draft, were designed for a working pressure of 2850 lb per sq in., but often pressures of 3100 lb, and even 3420 lb, were carried. The temperature of the steam varied from 700 to 750 F. The turbines had a single pressure stage, with two rows of buckets, or velocity staging.

A. PETERSON.[3]

[3] De Laval Steam Turbine Co., Trenton, N. J. Mem. A.S.M.E.

Diesel-Engine Maintenance, Operating, and Outage Data

TO THE EDITOR:

The author has made a real contribution in presenting the results of his experience with the operation and maintenance of Diesel engines,[4] and it is to be hoped that other papers on this subject will be forthcoming. Unfortunately, some of the data in this paper are not as specific as they might be, and, as the author points out, it applies to only one kind of Diesel application, that of electric generation for public-utility service.

Liner Wear. The following statement made in the paper is subject to misinterpretation:

> It is possible to show from these curves that if a fuel with 0.03 per cent ash were used, the life of liners might be as much as six to eight years, while if a fuel containing 0.08 per cent ash were used the life would be no greater than two years maximum. These life periods have been proved in actual practice.

Presumably, these life periods are based on continuous operation, 8760 hr per yr, and the life would, therefore, be over three times as long for applications where engines run only 2500 hr per yr, as is common in industrial private power plants.

Fuel Efficiency. While engine wear, undoubtedly, will, in time, reduce the fuel efficiency, the conclusion that the author reaches in the following statement is open to question:

> Engine wear, and particularly liner wear, also has a marked effect on engine efficiency. When a Diesel is purchased the engine manufacturer guarantees certain fuel rates at full, three-quarter, one-half, and one-quarter engine loadings—based on operation when engine is new and in first-class mechanical condition. Too frequently Diesel engineers and consultants make estimates with heat-rate figures that cannot be maintained during the life of an engine.

On the contrary, in most cases under the writer's observation, the fuel efficiency, for a considerable time after installation, has been materially better than either the builders' guarantees or the original acceptance-test results. This improvement occurs, presumably, because the liners and pistons become glossy, the bearings lose their roughness,

[4] "Diesel-Engine-Maintenance, Operating, and Outage Data," by Lee Schneitter, MECHANICAL ENGINEERING, vol. 59, 1937, pp. 83–88 and 102.

other friction losses are reduced, and cylinder blowby decreases.

In one industrial plant containing a 260-hp, 327-rpm engine, which has been in operation about 2500 hr annually for over 8 yr and for which accurate load and fuel-consumption records have been kept, the fuel efficiency, after 10 months of operation, was 8 per cent better than the acceptance test, which confirmed the builder's guarantee. After 18 months, the fuel efficiency had improved 22 per cent and, after 30 months, 27 per cent. The engine has received annual overhauls, at which pistons were cleaned and valves ground, but the cylinder liners have never been changed. Each year, the fuel efficiency has risen after the overhaul and then fallen before the next one; the efficiencies stated are the highest of each annual cycle. However, up to the end of the sixth year, the actual efficiency for any one month had never dropped below that shown on the acceptance test. At that time, it dropped to 5 per cent below and, after the overhaul, recovered to 12 per cent above. During the last or eighth year, the efficiency dropped 16 per cent below the acceptance-test figure for 2 months before the overhaul, after which it rose to within 3 per cent of the test figure. The fuel efficiency, averaged for the entire 8 years, has well exceeded the original acceptance-tests.

Similar results are shown for a 60-hp, 1200-rpm Diesel engine which has been operating from 17 to 24 hr per day in a machine shop. The fuel efficiency shown in the acceptance test immediately after installation was practically the same as that guaranteed. Seven months later, after running 2280 hr, the fuel efficiency was 13 per cent greater than the acceptance test, and, after 12 months or 4620 hr, the efficiency was 24 per cent better. After 15 months or 6056 hr, just before the liners and pistons were changed for reasons unrelated to fuel efficiency, the efficiency was still 20 per cent better than at the start. At latest reports, the engine had run 2330 hr with the new liners, and the fuel efficiency was then 22 per cent better than the acceptance test.

The cases previously cited are typical of those in the writer's experience and lead to the conclusion that actual fuel efficiency may be expected to exceed the initial efficiency throughout, at least, the first life cycle of the cylinder liners in actual service.

Labor Requirements. The author overestimates the attendance required in small plants, which seldom contain the large number of manually operated auxiliaries that he lists. The author states:

> Part-time attendants are sometimes provided in small plants, but if operators are to make regular inspections of equipment operating, they seldom can perform any great amount of other useful work.

Both of the plants whose fuel-efficiency records have been mentioned receive only part-time attendance. The 260-hp engine is attended by a toolmaker, who works in a room adjoining the engine room; actual count of his time spent attending the engine, including daily starting and stopping, has shown this to be only 1 hr per day. The remainder of his time is usefully employed in the toolroom.

The 60-hp high-speed engine is attended on the day shift by the shop electrician, who was a regular employee before the engine was installed and who is still able to perform his former duties in addition to attending the engine. On the night shifts, the engine is in charge of a machinist who leaves his machine tool running, while he goes for a few minutes at hourly intervals to inspect the engine.

In both plants, automatic alarms are installed to sound warnings in case of low lubricating-oil pressure or high water temperature, and continuous attendance would clearly be a waste of time.

E. J. KATES.[5]

TO THE EDITOR:

Presumably, the valuable data in this paper were assembled primarily for the use of those interested in the operating economics of the Diesel engine. Compiling such data entails a vast amount of tedious labor, and, therefore, some additional work would be justified in extending the benefits of such a compilation to other interested groups. The insurance carriers would be greatly interested in tabulations of breakdown and outages which would segregate engines having a closed cooling system from those with an open system. Some information as to accident-frequency comparisons between engines fully equipped with lubricating-oil and cooling-water failure-alarm devices and those not so protected would also be of value.

To be able to deduce, from the tabulated data, any relationship between breakdown frequency regarding the age of the engine, as for example, a comparison between engines built in the last 10 years with those built earlier, would also be of interest.

If the present paper does not make such a distinction, differentiating between outages due to accidents, such as actual breakage of important parts, and outages which might be classified under maintenance, would be of vital interest.

T. C. RATHBONE.[6]

TO THE EDITOR:

That the background for this paper is a body of data accumulated with great care over a number of years is quite evident. Fig. 1 alone must have required a long series of careful measurements with each of the many fuels used.

The casual reader ought to be warned, however, that much of the Diesel service described in the paper has about the same relation to average duty that proving-ground usage has to the requirements of the average automobile owner. Both the 3000- and the 990-kw plants were expected to deliver practically the rated output of all units practically every hour of the year, or what amounted to 8000 kwhr or better per annum per kilowatt installed. In the oil-engine power-cost report for 1935, records of the operation of 447 engines in that year are published. These engines were located in municipal, utility, and industrial plants on complete-power, base-load, peak-load, and stand-by duty. For 381 of these engines, hours of operation and the average loads carried are available, and these show that only 40 units were operated more than 6000 hr and, of these, only three averaged over 80 per cent of rating, although 20 additional units, operated less than 6000 hr, exceeded that average load.

The small number of units operated for long periods at heavy loads does not indicate any inability to perform under such duty, but that such loads are generally unavailable. The author's plants are as favored as the ice plant that can sell its peak output every day in all seasons. In the power business, the average base-load plant cannot get the base load for anything like 8000 hr per annum, and the complete power plant must often be operated at reduced load. Approximately 3000 kwhr per kw per annum is an average for the electric-light and power industry as a whole, including all types of prime mover.

Maintenance costs may be expected to be high under such conditions, and a considerable increase can easily be paid

[5] Consulting engineer, New York, N. Y. Mem. A.S.M.E.

[6] Fidelity & Casualty Co. of New York.

without wiping out the saving in fixed charges, which is over half of the average fixed cost per unit of output. Even so, the maintenance costs reported by the author seem to be somewhat high. Finding a parallel for his operation is difficult, but plant 54 of the cost report mentioned comes nearer than any other. This plant contained seven 600-bhp units and was built in 1925 and 1926. Data for nearly 3 years of operation are as follows:

Year	1930	1931	1932[a]
Average operation for each unit, hr	8659	8650	5781
Plant running capacity factor, per cent	99.9	95.6	95.1
Plant service factor, per cent	98.9	98.8	98.7
Cost of all repairs, mills per net kwhr[b]	0.81	1.37	0.53

[a] Only 8 months of 1932 are included; 1930 and 1931 are full years.
[b] Average for 2 yr and 8 months is 0.95 mills per net kwhr.

This report shows the fifth, sixth, and seventh year of operation at 95 per cent or higher capacity factor and for between 98 and 99 per cent of the hours in the calendar. The fuel used was 27 deg (A.P.I.) crude and the 1 per cent bottom sediment and water probably contained some sand. Of course, the record for the first to the fourth year inclusive is not known or whether or not liners were renewed. The fact remains, however, that the cost of all repairs for 161,625 engine-hr of operation, during which time 60,615,500 net kwhr was produced, was 0.95 mill per net kwhr.

The author's plants which furnished the data for Figs. 7 and 8 are said to have been "typical of municipal or utility plants serving small towns." The maintenance costs shown may be typical of some such plants but hardly of all. Plant 73 of the power-cost reports can be cited in this connection. This plant contains four 1250-bhp engines which were installed in 1923, 1926, 1927, and 1927, respectively. Based upon data for 1930 to 1935, inclusive, three of the units completed at least 32,000 hr of operation and the fourth, 50,000 hr at the end of 1935. The running capacity factors have averaged between 63 and 72 per cent. The fuel oil used has varied from $9^1/_2$ to 14 deg A.P.I. No record of liner renewals is found until 1932, but five were renewed in 1933, four in 1934, and five in 1935. Yet the costs for all repairs, including station equipment as a whole, were 0.11, 0.27, 0.18, 0.35, 0.41, and 0.45 mill per net kwhr for the last 6 yr, respectively. Over this period, no enforced shutdowns for any of the engines occurred.

The second and third engines of plant 52 each completed over 30,000 hr of operation at the end of 1935, averaging over 3750 hr per annum at 73 to 80 per cent running capacity factor. The costs for all repairs, including a prorata share of general station repairs, has been 0.42, 0.56, 0.71, and 0.70 mill per net kwhr for one of these units for the last 4 yr, respectively, and 0.46, 0.98, 0.62, and 0.72 for the other.

The only engine in plant 1061 is a 980-bhp unit installed in 1930. At the end of 1935, it had operated 21,268 hr at 83 to 97 per cent running capacity factor. No liners have been renewed to date. The costs for all repairs, including general station repairs, were 0.45, 0.73, 0.84, 1.32, 0.06, and 0.43 mill per net kwhr for the last 6 years, respectively.

These three illustrations were chosen because the engines in each case had operated an appreciable number of hours and considerable data on that operation are available. Doubtless, other illustrations could be found, some confirming these lower maintenance costs, perhaps some upholding the author. The point is that no one, two, or three plants can be typical of all. Considerably more enters into maintenance cost than hours of operation, per cent of rating carried, and grade of fuel—the quality of attendance for one thing, and no way to reduce that to "typical" conditions is known.

One can only speculate why the author's maintenance costs are as high as they are. These plants are necessarily old ones, otherwise, so many years of operation could not have been covered. Great advances in metallurgy, dynamic balancing, and design generally have been made in the last 10 years, advances that are not reflected in the design of engines built some years ago. Therein lies a big weakness of maintenance data; by the time such data become complete, they are no longer of value because they do not apply to modern machinery.

Possibly too much maintenance was deferred until the time for liner renewal, thus requiring an undue amount to correct aggravated conditions. The curves on decrease of capacity and increase of fuel consumption give some indication that this was the case. Returning to units two and three of plant 52, the output in gross kilowatthours per gallon of fuel was 10.81 and 11.13, respectively, in 1930 and 11.90 and 12.00 for slightly lower running capacity factors in 1935, and no liners were renewed meanwhile. Fuel economy will depend not only on the condition of liners but also upon maintenance of rings, valves, clearances, injection parts, and the like. If these items are allowed to deteriorate until a general overhaul, fixed in time by the necessity to renew liners, the reasonable expectation is that fuel consumption will increase and capacity will fall off.

Citing plant 73 in respect to fuel consumption would be unfair, for liners have been renewed, but none have been renewed in the other case given, namely, plant 1061. A much higher economy was reported for the first year of operation, 1930, but since then, the gross kilowatthours produced per gallon of fuel has remained almost constant except for the variation expected from that in the capacity factor, the figure for 1931 being 11.48 at 81.4 per cent and that for 1935 being 11.85 for 99.2 per cent.

The author presents impressive figures on Diesel-plant outages and one conclusion seems to be that outages due to engines averaged 6.5 per cent of demand hours. His definition of "outage" and the A.S.M.E. definition of "enforced shutdown" may not be equivalent, but comparing his figures with A.S.M.E. data for 1935 is interesting. Segregated enforced-shutdown and operating-hour figures can be obtained for a total of 310 engines in the 1935 report. These units operated 978,111 hr, had 167 enforced shutdowns aggregating 7966.4 hr, or 0.82 per cent of operating time, and, presumably, a slightly less percentage of demand time. If the data are confined to units that operated at 70 per cent running capacity factor or higher, segregated figures are given for 47 such, and these show that these units operated 125,554 hr with a total of 55 enforced shutdowns aggregating 3154.5 hr or 2.51 per cent of operating time. The median age of the 310 engines was 7 years of the 47 engines it was 6 years.

M. J. REED.[7]

TO THE EDITOR:

Accurately taken current wear records on the $11^1/_2$-in. bore and 15-in. stroke engines running at 400 rpm on our East Texas pipe line show an average wear of 0.0355 in. after 16,428 hr of operation. At one station, the engines averaged 26,239 hr of operation with an average wear of 0.0455 in. Fuel compares in ash content with the results given in Fig. 1 of the paper, which show 0.032 in. wear after 16,000 hr of operation.

These results, we believe, compare

[7] Diesel Engine Manufacturers' Association, New York, N. Y.

favorably with the figures presented by Mr. Schneitter if brake mean effective pressure, speed, and similar factors are taken into consideration. They check with the curves and prove that, on an equal ash basis, at least, predictions can be made for wear.

LESTER M. GOLDSMITH.[8]

TO THE EDITOR:

Mr. Kates feels that data in my paper apply only to Diesel engines for electric generation in public-utility service. This is true only for the section on maintenance; all other items mentioned in the paper, such as, liner wear, loss of engine capacity, decrease in efficiency, and outages, can be applied equally well to any slow-speed Diesel generating unit used for stationary service. He points out that liner life in an engine operating 2500 hr per year should be about three times that for an engine operating approximately 8000 hr. This is basically correct. The example for liner life cited in the text for fuels with 0.03 and 0.08 per cent of ash was based on 8000 hr operation per year, and naturally life periods would be extended if the engine operated fewer hours per year.

Two examples where fuel efficiency improved with age of engines are cited by Mr. Kates. I agree with him that nearly all engines will show some betterment in fuel rate after a reasonable "wearing-in" period, but my experience has been that all improvement possible will be realized after the first 1000 to 1500 hr of operation. Whether the improvement will cause the heat rate to be as much below engine manufacturers' guarantees as Mr. Kates shows is doubtful. Competition in engine sales is extremely keen, and engine manufacturers usually set the fuel rates rather low so that no betterment of any great value can be expected. The betterment in fuel efficiency, as related by Mr. Kates, is indeed remarkable. Possibly, these acceptance tests were run with poor-grade fuel of low-heating value to test the engine's ability to use a cheap fuel and that better grades of fuel were used later, which naturally improved the fuel-consumption rates. I mention this because he refers to fuel efficiencies and guarantees that usually relate to fuel consumption by weight rather than by heat consumption, and we all know that heating value and grade of fuel have considerable effect on the fuel-consumption rate. Mr. Kates' data on the 260-hp engine, which operated only 20,000 hr before liner replacements, show that the fuel efficiency changed from an 8 per cent improvement over the acceptance test for the initial running period to a 16 per cent deficiency at time of liner replacements, a reduction of 24 per cent comparing favorably with the 22 per cent loss given in my paper.

His remarks regarding part-time operating labor for small plants with single-engine units can be accepted for certain installations where continuity of service and engine regulation are not important factors. Small plants, such as those mentioned by Mr. Kates, are not comparable with the type of generating stations for which data on labor are shown; Fig. 4 showing Diesel-plant labor requirements covers plants from 400 to 8000 kw capacity only.

Mr. Rathbone requests that tabulations be extended to show the division of outages for plants of different types and for engines with different equipment and of different ages. The power-plant engineer is, of course, chiefly interested in outages from the standpoint of serviceability of the equipment installed, and the outage data were compiled for this purpose. His suggestions are appreciated, and the desired data can be included with further reports.

Mr. Reed infers that many of the data in the paper are based on plants or engines operating at full-rated capacity for 8000 hr or more per year. I cannot understand why he should make this mistake, because practically all of the data are actually based on regularly operated Diesel engines of average size and are directly applicable to all Diesels of the slow-speed stationary type; the only material for high-capacity plants is that referring to the maintenance curves of the 990-kw plant, Fig. 5, and the 3000-kw plant, Fig. 6. Most of the data refer to the average plant with an annual load factor around 35 per cent; the tabulations on maintenance, labor, and outage data specifically show that all 25 plants, including 75 engines, were operated over a three-year period with an annual load factor averaging only 36.9 per cent.

Much discussion is presented by Mr. Reed to show that the maintenance costs per unit of output shown in Figs. 5, 6, 7, and 8 are high. There was no desire to fix the magnitude of the maintenance costs shown in my paper; all maintenance curves are intended to explain why unit costs vary with different kinds of plant and operating conditions and, furthermore, to show definitely that all plants are subject to characteristic cycles of maintenance costs with peaks occurring at certain periods. Maintenance data presented in Fig. 5 were taken from a plant with engines that would be considered of old design today, and I agree with Mr. Reed that these maintenance values are higher than would be expected of modern engines. Data presented in Figs. 6, 7, and 8 were taken from plants with engines that compare favorably with engines of present-day designs. He feels that improvements made in Diesel-engine design in the last ten years should lead us to question the value of past maintenance records. Naturally, some improvement has been made on all types of Diesels, but the developments Mr. Reed refers to have taken place mainly in the class of so-called high-speed Diesels which are not discussed in the paper. Slow-speed, stationary engines of older designs will sell for premium prices today because of their conservative design as to weight per horsepower, piston speed, mean effective pressure, and the like, and no reason exists for believing that their maintenance records will be improved by the more modern higher-speed engines built to sell in a highly competitive market.

Maintenance-cost figures on plant No. 54, which are from A.S.M.E. Oil-Engine Power Cost Report of 1932, may be reliable but some question might be raised on this point because the plant was installed in 1925–1926 with a maintenance guarantee by the engine manufacturer. Plant No. 73 has been scrutinized by members of the Power Cost Committee for reporting unreasonably low maintenance costs, and referring to these costs is unreasonable, when so many other plants in the report could be used in a study of true maintenance cost. Maintenance figures on plant No. 1061 substantiate some of the yearly fluctuations in maintenance costs that were pictured in my paper. While this plant has operated over a period of 6 years, the engine has actually run less than $2^1/_2$ years and higher costs would be natural when liner replacements and general overhaul are necessary. The engines at plant No. 52 referred to by Mr. Reed have evidently been used for reserve units, which accounts for the low maintenance costs at this plant. The records show the first units were installed in 1928, but new engines were added to the plant in 1930, 1933, and 1936 and were used for base-load service so that none of these engines ever reached the stage of requiring major overhaul. Low maintenance costs should be expected under this particular plant condition.

Mr. Reed's analysis of enforced shut-

[8] Manager, general construction and engineering department, The Atlantic Refining Company, Philadelphia, Pa. Mem. A.S.M.E.

downs as shown in the A.S.M.E. Oil Engine Power Cost Report is interesting. Naturally, lost time due to enforced shutdowns is much less than total outages because a forced shutdown is only one of several reasons for an outage. Also, repairs made during enforced shutdown are hurried and frequently temporary with as little lost time as possible, the major time lost for permanent repairs being charged to some later shutdown period. The Diesel-engine user or prospective purchaser should be more interested in total outage time as related to demand hours, hours that the engine is required for service, rather than the item of enforced shutdowns.

Kenneth Hollister asked[9] if the individual data used in making Fig. 1 were more or less of a "shot-gun" type, or if all data closely follow the general curve. He felt that other factors, such as lubrication, would have an effect on liner wear. Fig. 1 was carefully prepared from actual data. The shape of the basic curve was first established by checking liner wear at one plant where all operating conditions were fixed. One grade of lubricating oil was used for many years, and no important change in any plant condition occurred, the only change being the grade of fuel used. With one grade, liner wear was at a certain rate per thousand hours' running time. With other fuels having a different ash content, the rate of wear was different. Results at other plants were also noted every time fuels were changed. Since several of the Diesel plants were in foreign installations, an exceptionally good opportunity was afforded to try out fuels from different suppliers and several fields. After the general shape of the curve was fixed, data were added from as many plants as possible; it was found that the curves as first drawn and as presented in the paper served very well for all data from all sources.

In answer to Mr. Wallace's question[9] regarding the percentage of availability in a 2000-hp installation, the ratio of service hours to demand hours, commonly termed service-demand availability factor, would depend on design of engine, bases for rating, slow or high speed, and similar factors, and of course, on the nature of service requirements, load conditions, and the like. For slow-speed stationary engines for power-plant service and where overloading is not required, reliable records clearly show that the demand availability factor will be approximately 90 per cent. For high-speed engines and for slow-speed engines operated on sustained loads of greater than 85 per cent rating, the availability factor would be somewhat less.

No reference to fixed charges was made in the paper. I assume that Mr. Wallace has in mind the question of depreciation which was not in the scope of this paper. Fixed charges should be included in all studies involving the economics of a Diesel installation, and this is an important item. The magnitude of the fixed charges would depend on factors outside of an engine's physical life and discussion of this subject would be too involved to engage in at this time.

Purchasing uniform fuel of suitable quality is important for any Diesel and the engine manufacturer should be consulted on fuel grade for any particular engine type. Engine capacity, efficiency, availability, and general reliability depend on the grade of fuel used. Engines can be adjusted to a certain extent to operate on inferior grades of fuel but are not reliable to the extent of obtaining maximum availability. Where price is not important, fuel for Diesels should be purchased under carefully defined specifications.

Giving a direct answer to Mr. Wallace's question about the normal life of a Diesel engine is difficult, because the period, during which an engine shall be kept in active service and during which it should be written down to a small percentage of original cost, depends on both physical and economic factors. For an industrial installation, arranging for amortization in five years or less is often desirable, because of uncertainties attending industrial operations, in addition to elements bearing on the physical life of the engines themselves. For municipal or utility enterprises, a prudent and conservative course is to arrange for amortization of engines in 10 years; the maximum useful life that should be assumed is 15 years, even though physical life may exceed that under favorable conditions.

Physical life depends upon engine speed and general design, care and competence of operation and maintenance, and character of service but is not as important as other factors in determining useful or economic life. Slow-speed engines of proved design may be assigned a physical life of 15 years while high-speed engines may last only from 5 to 8 years. When long physical life is desired, great care should be used to select a type of engine that is suitable to the service.

LEE SCHNEITTER.[10]

[9] When the paper was presented.—Ed.

[10] Plant Betterment Engineer, Ebasco Services, Inc., New York, N. Y. Mem. A.S.M.E.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following is a record of the interpretation of this Committee formulated at the meeting of March 12, 1937, and was subsequently approved by the Council.

CASE No. 835 (Reopened)

(*Interpretation of Pars. P-268 and U-59*)

Inquiry: In welding an inserted type nozzle as shown in Fig. 34, should the joint be radiographed?

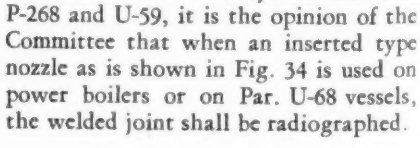


FIG. 34 INSERTED TYPE NOZZLE

Reply: Whereas Figs. P-6 and U-6 show some types of acceptable nozzles which need not be X-rayed under Pars. P-268 and U-59, it is the opinion of the Committee that when an inserted type nozzle as is shown in Fig. 34 is used on power boilers or on Par. U-68 vessels, the welded joint shall be radiographed.

CASE No. 839

(Annulled)

Revisions and Addenda to Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later in the proper place in the Code.

The following proposed revisions have been approved for publication as proposed addenda to the Code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticism and approval from any one interested therein. It is to be noted that a proposed revision of the Code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

Preamble. Insert the following preceding Par. P-1:

A pressure vessel in which steam is generated by the application of heat resulting from the combustion of fuel (solid, liquid, or gaseous) shall be classed as a steam boiler.

Flash-type boilers or those having a forced circulation with no fixed steam and water line—the material for these shall conform to the requirements of the Code. All other requirements shall also be met except where they relate to special features of construction made necessary in boilers of these types, and to accessories that are manifestly not needed or used in connection with such boilers, such as water gages, water columns, and gage cocks.

An unfired pressure vessel which generates steam for power or heat to be used externally to itself shall be classed as an unfired steam boiler. Such vessels may be constructed under the appropriate classification of the Unfired Pressure Vessel Code and shall be equipped with the safety devices required by the Power Boiler Code in so far as they are applicable to the service of the particular installation.

These rules apply to the boiler proper and pipe connections up to and including the valve or valves as required by the Code.

Where forces other than those provided for in the Code are applied to steam boilers or other pressure vessels, the stress imposed by such forces must be calculated and additional strength provided to withstand them, using a factor of safety not less than that prescribed for similar conditions in the Code.

PAR. P-26. Present paragraph to be designated as (*a*). Add the following as (*b*):

b Other non-ferrous materials where used in accordance with the provisions of the code shall meet the requirements of the specifications for non-ferrous materials given in Section II of the code and the working stresses in the materials shall not exceed the values given in Table P-7$^1/_2$.

PARS. P-102 and U-68. Add the following:

j The manufacturer shall be responsible for the quality of the welding done by his organization and shall conduct tests of welding operators to determine their ability to produce welds of the required quality.

The manufacturer shall satisfy the inspector that all the welding operators employed on a boiler drum or pressure part of a unit have previously made test plates which comply with the requirements of the code. Such test plates shall have been made within a period of six months, except that when the welding operator is regularly employed on production work embracing the same process and type of welding the tests may be effective for one year.

It is the duty of the inspector to satisfy himself that only welding operators who are proved competent by these test plates are used to weld any pressure part and that all welding complies with the code requirements.

The inspector has the right at any time to call for and witness the making of test plates described in this paragraph by any welding operator and to observe the physical tests of them. For such qualification tests, the thickness of the test plate shall be not less than the approximate thickness of the plate or parts on which the welding operator is to work.

When more than one welding operator is employed on a boiler drum, the required test plates for the individual vessels shall be made by the welding operator designated by the inspector.

The tests conducted by one manufacturer shall not qualify a welding operator to do work for any other manufactuer.

PAR. P-109*a*. Modify proposed revision of first sentence appearing in May, 1937, issue, to read:

All fusion-welded drums and other pressure parts shall be subjected to the hydrostatic pressure prescribed in Par. P-329, and while subject to this pressure all butt-welded joints WHICH ARE UNSUPPORTED BY OTHER MEANS, AND ALL OTHER WELDED JOINTS WHERE SUCH A TEST IS FEASIBLE shall be given a thorough hammer or impact test.

PAR. P-180. Add the following to the definition of *R:*

In a locomotive-type boiler with a tapered course, the radius shall be the maximum in such course.

PAR. P-186*e*. Revise to read:

e The ends of inner butt straps of riveted butt-strap longitudinal joints may be fusion welded to the edges of heads OR OF THE ADJOINING SHELL PLATE, or to circumferential butt straps for tightness, provided the carbon content in the steel does not exceed 0.30 per cent. WHEN THE BUTT STRAP OF A LONGI-

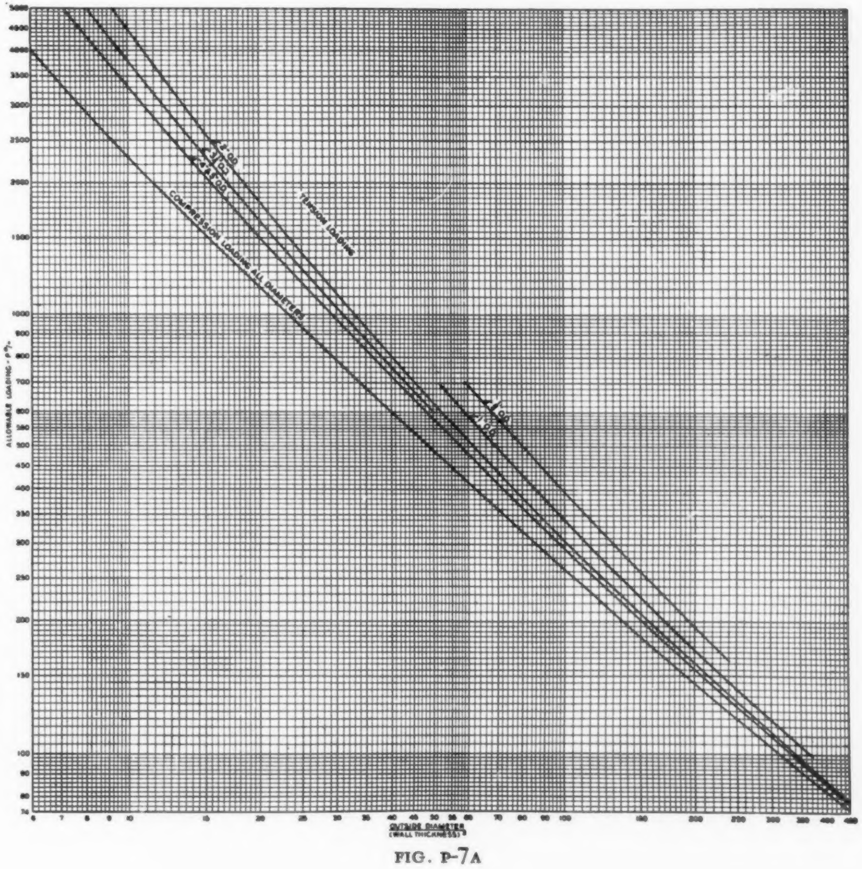


FIG. P-7A

TUDINAL JOINT DOES NOT EXTEND THE FULL LENGTH OF THE SHELL PLATES, AS SHOWN IN FIG. A-00, THE ABUTTING EDGES OF THE SHELL PLATE MAY BE WELDED PROVIDED THE DISTANCE FROM THE END OF THE BUTT STRAP TO THE EDGE OF THE FLANGE OF THE HEAD OR ADJACENT SHELL PLATE IS NOT GREATER THAN $2^1/_2$ IN.

PAR. P-186. Insert the following as (*e*).

Allowable Loading on Structural Attachments to Tubes. e The maximum load per inch of length of steel tube imposed by welded or mechanical attachments to tube walls which produce bending stresses that are additive to bursting stresses shall not exceed values given by the following formula:

$$P = \frac{Wr}{l} \pm \frac{6We}{l^2}$$

P = allowable load lb per sq in. from chart in Fig. P-7*A*
W = load applied to lug, lb
Wr = load component normal to tube axis, lb
l = length of attachment on tube, in.
e = eccentricity of W, in. (see Fig. P-7B).

In determining the allowable loading per inch of length of attachment on a tube bend, the allowable load determined by using the outside diameter of the tube shall be increased by the amount of allowable-compression load for a tube having an outside diameter equivalent to the outside diameter of the bend and having a wall thickness the same as that of the tube bend (see Fig. A-12d).

Pars. A-70 to A-73 of the Appendix give illustrative examples of the application of the above rules for the several loading conditions, as shown in Fig. A-12.

Illustrative Methods of Computation of Attachments to Tubes

A-70. A tube is suspended by welded attachment with the loads and dimensions as shown in Fig. A-12*a*. This is a condition of direct radial loading on the tube.

Allowable unit load P:

$$\frac{D}{t^2} = \frac{4}{0.300^2} = 44.4 \quad P = 685 \text{ lb per sq in.}$$

tension from chart in Fig. P-7A.

Actual unit load:

$$W = 1500 \text{ lb} \quad P = \frac{1500}{3} = 500 \text{ lb per sq in.}$$

tension.

The loading indicated is therefore within the values allowed by the chart, Fig. P-7A.

A-71. A load is supported on a rubbing strip welded to a tube, as shown in Fig. A-12*b*. This problem illustrates a condition where the loading is not applied on the center of the welded attachment.

Allowable unit load P:

$$\frac{D}{t^2} = \frac{4}{0.300^2} = 44.4; \; P = 660 \text{ lb per sq in.}$$

tension = 555 lb per sq in. compression

Actual unit load:

$$W = 960 \text{ lb}; \; P = \frac{960}{4} \pm \frac{6 \times 960 \times .875}{4^2} =$$

$240 \pm 315 = 555$ lb per sq in. compression = 75 lb per sq in. tension

The actual loading does not exceed values of allowable loading.

A-72. A load is supported from a vertical tube with a welded bracket attachment as shown in Fig. A-12*c*. This example illustrates a condition of eccentric loading where the direct loading is not additive.

Allowable unit load P:

$$\frac{D}{t^2} = \frac{3.25}{.375^2} = 23.11; \; P = 1000 \text{ lb per sq in.}$$

compression

Actual unit load:

$$W = 440 \text{ lb}; \; P = \frac{6 \times 440 \times 1.5}{2^2} = 990 \text{ lb}$$

per sq in. compression or tension

A-73. A superheater section is supported by welded attachment to the short radius return bend section as shown in Fig. A-12*d*. This example illustrates a condition where a direct and eccentric load is applied to a bent tube section.

Allowable unit load P:

$$\frac{D}{t^2} = \frac{2}{0.300^2} = 22.2; \; P = 1050 \text{ lb per sq in.}$$

compression = 1600 lb per sq in. tension

$$\frac{D}{t^2} = \frac{6}{.300^2} = 66.6; \; P = 380 \text{ lb per sq in.}$$

compression = 380 lb per sq in. tension

Total allowable P = 1430 lb per sq in. compression = 1980 lb per sq in. tension

Actual unit load:

$$P = \frac{750}{2.5} \pm \frac{6 \times 1200 \times .75}{2.5^2} = 300 \pm 864 =$$

1164 lb per sq in. compression = 564 lb per sq in. tension

The actual applied load is less than the values allowed by the chart in Fig. P-7A.

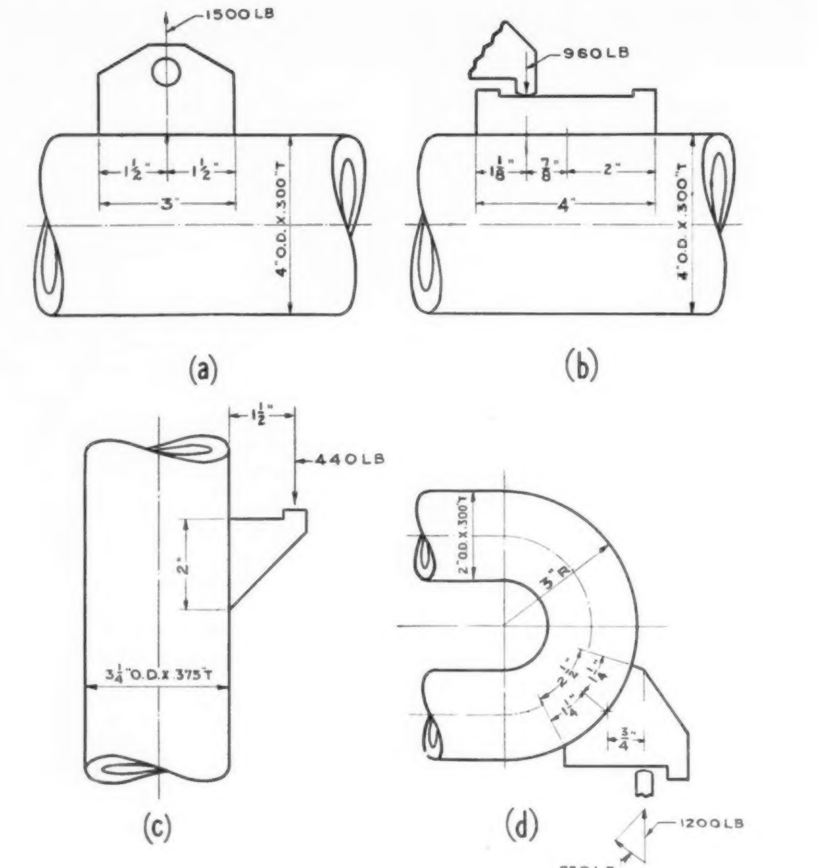


FIG. A-12

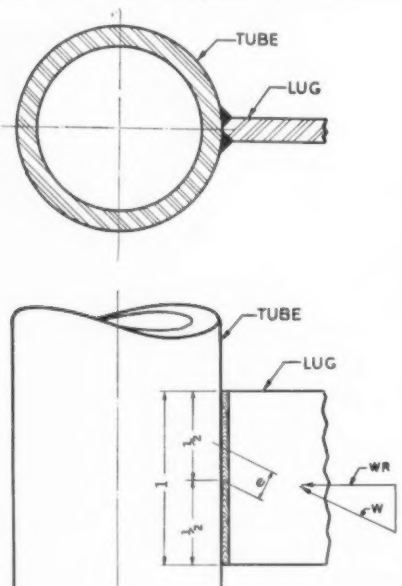


FIG. P-7B

PAR. P-194. Add the following as (*b*):

b In a locomotive-type boiler with a dome on a tapered course, the maximum allowable

diameter of the dome shall be based on that diameter of the tapered course which intersects the axis or center line of the dome.

PAR. P-218. Add the following:

When horizontal fire-tube boilers are set so that the products of combustion do not come in contact with the lower part of the shell, tubes may be used instead of through stays at the sides of the manhole opening, if used.

PAR. P-269. Present paragraph to be designated (*a*). Add the following as (*b*):

b Safety valves may be of bronze complying with Specification S-41, for temperatures not exceeding 500 F and in which the maximum allowable working stress does not exceed the values given in Table P-7½.

TABLES P-7½ and U-3¾. Add the following:

Material	Spec. no.	For metal temperatures not exceeding —deg F— 150	250	350	406	450	500
Steam Bronze	S-41*	6800	6250	5750	5450	5250	5000

* A.S.T.M. Spec. B61-36.

PAR. P-299. Add the following:

j Bronze fittings or valves shall be of material conforming to Specification S-41 and shall not have allowable working stresses exceeding those given in Table P-7½ nor be used for temperatures exceeding 500 F.

PAR. P-317. Revise (*d*) to read:

d A combination stop-and-check valve IN WHICH THERE IS ONLY ONE SEAT AND DISK AND A VALVE STEM IS PROVIDED TO CLOSE THE VALVE WHEN THE STEM IS SCREWED DOWN shall be considered only as a stop valve, and a check valve shall be installed as otherwise provided.

In (*b*) change the expression "and/or check valve" to "and a check valve;" In (*e*) omit the expression "in such an arrangement."

PAR. H-12. Revise to read:

H-12. The minimum thickness of shell AND OTHER plates, heads, and tube sheets for various shell diameters of steel plate heating boilers shall be as shown in Table H-1. ALL SHEETS SUPPORTED BY BRACES OR STAYBOLTS MAY BE CLASSIFIED AS SHELL PLATES. [For the purpose of applying Table H-1 to a non-cylindrical boiler, the equivalent shell diameter shall be taken as the width of the unsupported portion of any plate.]

TABLE H-1. Reverse the second and third columns so that the one reading "Tube sheet or head" comes first, and make the heading of the second column read "Shell or other plate."

PAR. U-1. Add the following as (*c*):

c The Code for Unfired Pressure Vessels does not cover all types of vessels. The code symbol shall not be applied to any vessel, the material for the pressure parts of which does not all comply with the code rules or the type of construction is not sanctioned by the rules.

PAR. U-4. Insert the following:

U-4. The pressure at which a safety device is set to operate must include the effect of static head, if any, at the place at which it is connected.

PAR. U-19. Revise to read:

U-19 The maximum allowable working pressure is THAT DETERMINED BY EMPLOYING THE FACTORS OF SAFETY, STRESSES, AND DIMENSIONS DESIGNATED IN THESE RULES. NO UNFIRED PRESSURE VESSEL SHALL BE OPERATED AT A PRESSURE HIGHER THAN THE MAXIMUM ALLOWABLE WORKING PRESSURE EXCEPT WHEN THE SAFETY DEVICE IS BLOWING, AT WHICH TIME THE MAXIMUM ALLOWABLE WORKING PRESSURE SHALL NOT BE EXCEEDED BY MORE THAN 10 PER CENT [the maximum pressure at which a pressure vessel may be operated.]

Whenever the term "maximum allowable working pressure" is used it refers to gage pressure or pressure above the atmosphere in pounds per square inch.

PAR. U-20. Add the following:

e Bronze Castings. The maximum allowable working stresses in fittings and valves (including safety valves) made of bronze conforming to Specification S-41 shall not be in excess of the values given in Table U-3¾.

Add the following as (*f*):

f The Code provides the limiting stresses for use in the design of pressure vessels and it is necessary to take account of the effect of static head that may be produced in any part in order that such stress limits be not exceeded.

PAR. U-36*f*. Add the following:

Dished heads with a reversed flange having pressure on the concave side of the dish may be used only when the requirements of Par. U-51 are met.

PAR. U-59. Rescind proposed addition to (*p*) as published in March issue. Revise (*q*) to read:

q WHEN connections ARE attached by fusion welding to A forge-welded, riveted, brazed or seamless vessel, THE VESSEL SHALL BE STAMPED U-68, U-69, OR U-70 AS REQUIRED BY PAR. U-66 AND IN ACCORDANCE WITH THE SERVICE LIMITATIONS AS TO PRESSURE, TEMPERATURE, ETC., AS THE CASE MAY BE, AND THE REQUIREMENTS FOR WELDING AND STRESS RELIEVING OF FUSION-WELDED CONNECTIONS AS GIVEN IN (*O*) AND (*P*) ABOVE SHALL APPLY [shall be stress relieved in accordance with the requirements for connections on vessels built in accordance with Par. U-69. If any such vessels are to be used for service equivalent to fusion welding as provided in Par. U-68, then any fusion-welded connection must be stress relieved].

PAR. U-68*a*. Add the following:

The plates for test samples may be taken from any part of one or more plates of the same lot of material that is used in the fabrication of the welded vessels and without reference to the direction of the mill rolling.

PAR. U-72*j*. Add the following:

These requirements are not intended to apply to any process of welding by which proper fusion and penetration are otherwise obtained and no impurities remain at the base of the weld.

PAR. U-76*f*. Add the following:

Heavy attachments such as supporting lugs which are fusion welded to vessels shall be stress relieved if the vessel itself requires stress relieving. Attachments, the failure of which would not affect the safety of such vessels, need not be stress relieved provided the welds comply with the requirements of Par. P-186 of the Code for the tack welding of non-pressure parts.

PAR. U-69. Revise third section to read:

Welding shall meet the following test requirements BASED ON THE QUALIFICATION-TEST PROCEDURE GIVEN IN PARS. UA-30 TO UA-46.

Replace the first section of (*a*) by the following:

a Each manufacturer or contractor shall be responsible for the quality of the welding done by his organization and shall conduct tests not only of the welding process to determine its suitability to insure welds which will meet the required tests, but also of the welding operators to determine their ability to properly apply the procedure.

Revise the fourth section of (*a*) to read:

The manufacturer shall maintain a permanent record on the recommended form shown on page 76 of the welding operators employed by him, showing the date and result of the tests and the identification mark assigned to each. These records shall be certified to by the manufacturer and accessible to the inspector. An authorized inspector shall have the right at any time to call for and witness tests of the welding process or of the ability of any welding operator.

Replace all of (*b*) by the following:

b Test Welds. For the qualification of a welding process, the number, type, and size of test welds shall comply with Par. UA-34.

For the testing of a welding operator, the number, type, and size of test welds shall comply with Par. UA-42.

Replace all of (*c*) by the following:

c Test Specimens. For the qualification of a welding process, the number, type, and preparation of test specimens shall comply with Par. UA-36.

For the testing of a welding operator the number, type, and preparation of test specimens shall comply with Par. UA-44.

Replace all of (*d*) by the following:

d Test Results. The minimum requirements for test results in the *qualification of a welding process* are as follows:

Tensile Strength. For the reduced-section tension-test specimens the tensile strength shall be not less than 95 per cent of the minimum of the specified tensile range of the plate used for double-welded butt joints, or 85 per cent for single-welded butt joints. (The tension of the joint specimen as specified herein is intended as a test of the welded joint and not of the plate.)

Free-Bend Ductility. The ductility requirement by the free-bend-test method shall be not less than 20 per cent.

Soundness. The root-break, side-break, and nick-break tests of the weld shall show in the fractured surface complete penetration through the entire thickness of the weld, absence of oxide or slag inclusions, and a degree of porosity not to exceed six gas pockets per square inch of the total area of the weld surface exposed in the fracture, the maximum dimension of any such pocket not to be in excess of $^1/_{16}$ in., or provided the total area of the gas pockets per square inch does not exceed the area of six gas pockets each $^1/_{16}$ in. in diameter.

X-ray tests of the test plates as provided for in Par. U-68*i* may be substituted for the nick-break test.

The minimum requirements for test results in the *testing of a welding operator* are the same as above specified for soundness.

PAR. U-70. Revise the fourth section to read:

Welding shall meet the following test requirements BASED ON THE QUALIFICATION TEST PROCEDURE GIVEN IN PARS. UA-30 TO UA-46.

Replace the first section of (*a*) by the following:

a Each manufacturer or contractor shall be responsible for the quality of the welding done by his organization and shall conduct tests not only of the welding process to determine its suitability to insure welds which will meet the required tests, but also of the welding operators to determine their ability to properly apply the procedure.

Revise fourth section of (*a*) to read:

The manufacturer shall maintain a permanent record on the recommended form shown on page 76 of the welding operators employed by him, showing the date and result of the tests and the identification mark assigned to each. These records shall be certified to by the manufacturer and accessible to the inspector. An authorized inspector shall have the right at any time to call for and witness tests of the welding process or of the ability of any welding operator.

Replace all of (*b*) by the following:

b Test Welds. For the qualification of a welding process, the number, type, and size of test welds shall comply with Par. UA-34.

For the testing of a welding operator, the number, type, and size of test welds shall comply with Par. UA-42.

Replace all of (*c*) by the following:

c Test Specimens. For the qualification of a welding process, the number, type, and preparation of test specimens shall comply with Par. UA-36.

For the testing of a welding operator, the number, type, and preparation of test specimens shall comply with Par. UA-44.

Replace all of (*d*) by the following:

d Test Results. The minimum requirements for test results in the *qualification of a welding process* are as follows:

Tensile Strength. For the reduced-section tension-test specimen the tensile strength shall be not less than 85 per cent of the minimum of the specified tensile range of the plate used. In no case shall the tensile strength be less than 42,000 lb per sq in. (The tension test of the joint specimen as specified herein is intended as a test of the welded joint and not of the plate.)

Free Bend Ductility. The ductility requirement by the free-bend-test method shall be not less than 10 per cent.

Soundness. The root-break, side-break, and nick-break tests of the weld shall show in the fractured surface complete penetration through the entire thickness of the weld, absence of oxide or slag inclusions, and a degree of porosity not to exceed six gas pockets per square inch of the total area of the weld surface exposed in the fracture, the maximum dimension of any such pocket not to be in excess of $^1/_{16}$ in., or provided the total area of the gas pockets per square inch does not exceed the area of six gas pockets each $^1/_{16}$ in. in diameter.

X-ray tests of the test plates as provided for in Par. U-68*i* may be substituted for the nick-break test.

The minimum requirements for test results in the *testing of a welding operator* are the same as above specified for soundness.

RULES FOR QUALIFICATION OF WELDING PROCESS AND TESTING OF WELDING OPERATORS

Part I Qualification for Welding Process

UA-30 *Limitation of Variables.* For the qualification of each welding process the manufacturer shall establish and record as a *Process Specification* the definite limits of all essential variables involved, and in the investigation of each welding process the Process Specification shall be followed. The Process Specifications shall cover the following items: Process, base metal, filler metal, preparation of base material, nature of welding flame, nature of electric current and current characteristics, method of welding, number of layers or beads, shielding of arc or flame, cleaning or peening, removal of defects, treatment of underside of groove, heat-treatment.

UA-31 *Types of Test and Purpose.* The types of tests outlined below are to determine the tensile strength, ductility, and lack of soundness of welded joints made under a given Process Specification. Whereas some of the required tests are intended solely for the determination of lack of soundness, all types of test specimens shall be examined for lack of soundness if failure occurs in the welded joint. Lack of fusion or root penetration, cracks, slag, and gas inclusions constitute lack of soundness. The tests required are as follows:

For all types of welded butt joints

(*a*) Reduced-section tensile test: For tensile strength and lack of soundness of welded joints

(*b*) Free-bend test: For ductility of weld metal in welded joints and lack of soundness of joint

(*c*) Root-break test: For lack of soundness of welded joints

(*d*) Side-break test: For lack of soundness of welded joints

(*e*) Nick-break test: For lack of soundness of weld metal in welded joints.

UA-32. *Base Material and Its Preparation.* The base material and its preparation for welding shall comply with the Process Specification. For all types of welded joints the length of the weld and the dimensions of the base material shall be such as to provide sufficient material for the test specimens called for hereinafter.

UA-33. *Position of Test Welds. a Classification of Position.* All welds that will be encountered in actual construction shall be classified as being in the (1) flat, (2) horizontal, (3) vertical, or (4) overhead position depending upon the manner in which the weld metal must be deposited.

b Butt Joints in Plate. In making the test welds for butt joints in plate, the test plates shall be placed in an approximately horizontal plane for the (1) flat and (4) overhead positions, and in an approximately vertical plane for the (2) horizontal and (3) vertical positions. The weld metal shall be deposited from the upper side of the test plates for the flat position, and from the under side thereof for the overhead position. The test welds shall be run horizontally for the horizontal position and vertically for the vertical position.

UA-34. *Number, Type, and Size of Test Welds. Butt Joints in Plate.* For butt joints in plate two test welds shall be made for each process and position to be used in construction. One test weld shall be made in the minimum thickness and one in the maximum thickness of material that will be used in construction except that the thickness shall not exceed that permitted for the particular class of vessels under construction.

Lap Joints in Plate for Par. U-70 Vessels. If lap joints are to be used in the construction of Par. U-70 vessels, two single-welded butt joints shall be made for each process and position to be used in construction. One test weld shall be made in a plate thickness equal to the maximum size single pass fillet weld and one in the plate thickness equal to the minimum size multiple pass fillet weld that will be used in construction, except that in no case may the plate thickness for such test welds exceed $^3/_8$ in.

UA-35 *Welding Procedure.* The welding procedure shall comply in all respects with the Process Specification established by the manufacturer.

UA-36. *Test Specimens—Number, Type, and Preparation. Butt Welded Joints.* From each test weld there shall be taken the following test specimens which shall be prepared for testing as shown in the figures referred to:

For single-welded butt joints in plate: Two reduced-section tensile specimens, Fig. UA-7;[1] two free-bend specimens, Fig. UA-8;[2] two root-break specimens, Fig. UA-9;[3] two side-break specimens, Fig. UA-10;[4] two nick-break specimens, Fig. UA-11.[5]

For double-welded butt joints in plate: Two reduced-section tensile specimens, Fig. UA-7; four free-bend specimens, Fig. UA-8; two side-break specimens, Fig. UA-10; two nick-break specimens, Fig. UA-11.

UA-37. *Method of Testing Specimens. a Reduced-Section Tensile Specimens.* Before

[1] Fig. 3 of A.W.S. Tentative Rules for Qualification of Welding Processes and Testing of Welding Operators.

[2] Fig. 4, Ibid.

[3] Fig. 5, Ibid.

[4] Fig. 6, Ibid.

[5] Fig. 7, Ibid.

testing, the width, thickness and cross-sectional area at the weld shall be recorded. Each specimen shall be loaded in tension at a uniform rate until fracture occurs, and the maximum load in pounds shall be recorded. The tensile strength shall be recorded as the maximum load divided by the cross-sectional area as above recorded. If failure occurs in the welded joint, the fractured surfaces shall be examined for lack of soundness.

b Free-Bend Test Specimens. For single-welded butt joints the scribed lines shown in Fig. UA-8 shall be on the surface opposite the root of the weld. For double-welded butt joints the scribed lines on two of the specimens shall be on one surface of the weld and on the other two specimens shall be on the opposite surface of the weld. The distance between the scribed lines is to be measured in $^1/_{100}$ part of an inch and this measurement recorded as the initial gage length.

Initial bends shall be made as shown by the broken lines in Fig. UA-12[6] and in all cases the initial bends shall be in the same relation to the scribed lines as shown in Fig. UA-12.

The specimen with the initial bend at each end shall be placed as a strut in a vise or compression machine and pressure applied gradually (that is, without shock) at the ends until failure occurs in the outside fibers of the bend specimen. When a crack is observed in the convex surface of the specimen between the edges, the specimen shall be considered to have failed and the test shall be stopped. Cracks at the corners of the specimens shall not be considered as a failure. The appearance of small defects in the convex surface shall not be considered as a failure if the greatest dimension does not exceed $^1/_{16}$ in. The specimen shall then be removed from the vise or machine and the maximum distance between the scribed lines measured on the curved surface in $^1/_{100}$ part of an inch, this measurement being recorded as the final gage length. This measurement may be made by means of a flexible scale. The difference between the final and initial gage lengths divided by the initial gage length shall be recorded as the percentage of "free bend ductility." The specimen shall then be replaced in the vise or compression machine and pressure again applied until the specimen is broken in two or until it is bent flat upon itself. If the specimen breaks in the welded joint the surface of the fracture shall be examined for lack of soundness.

c Root-Break Specimens. The specimen shall be supported and pressure applied as shown in Fig. UA-13.[7] The root of the weld shall be opposite the side upon which pressure is applied. If fracture of the specimen does not occur using the method shown in Fig. UA-13, the specimen shall be removed from the fixture shown and pressure shall then be applied to the specimen in the direction *AA* until fracture occurs or the specimen is bent flat upon itself. The surface of the fracture shall be examined for lack of soundness.

d Side-Break Specimens. The specimen shall be supported and pressure applied as shown in Fig. UA-14.[8] If fracture of the specimen does not occur using the method shown in Fig. UA-14, the specimen shall be removed from the fixture shown and pressure shall then be applied to the specimen in the direction *AA* until fracture occurs or the specimen is bent flat upon itself. The surfaces of the fracture shall be examined for lack of fusion.

e Nick-Break Specimens. The specimen shall be supported as shown in Fig. UA-15[9] and broken by a sudden blow or blows applied at the center of the weld. The blow should be applied preferably by a power hammer or falling weight, and be of sufficient intensity to cause a sharp sudden fracture of the specimen through the nicked portion. The surfaces of the fracture shall be examined for lack of soundness.

Part II Qualification Tests of Welding Operators

UA-38. For the qualification of an operator under any welding process that has been qualified as outlined in Part I, the following procedure shall be used.

UA-39. *Types of Test Required.* The tests required for the qualification of an operator are limited to those intended for determination of lack of soundness. For each process an operator need be qualified only for the types of joints and positions that he will encounter in construction. The types of tests required are as follows:

A Single-welded butt joints: (a) Face-break test, (b) Root-break test, (c) Side-break test.

B Double-welded butt joints: (a) Face-break test, (b) Side-break test.

UA-40 *Base Material and Its Preparation.* The base material and its preparation for welding shall comply with the Process Specification. For all types of welded joints the length of the weld and the dimensions of the base material shall be such as to provide sufficient material for the test specimens called for hereinafter.

UA-41. *Position of Test Welds. a Classification of Position.* The classification of position shall be the same as specified in Par. UA-33*a*, namely, (1) flat, (2) horizontal, (3) vertical, (4) overhead.

b Butt Joints in Plate. In making the test welds for butt joints in plate, the test plates shall be placed in an approximately horizontal plane for the (1) flat and (4) overhead positions, and in an approximately vertical plane for the (2) horizontal and (3) vertical positions. The weld metal shall be deposited from the upper side of the test plates for the (1) flat position, and from the under side thereof for the (4) overhead position. The test welds shall be run horizontally for the (2) horizontal position and vertically for the (3) vertical position.

UA-42. *Number, Type, and Size of Test Welds. Butt Joints in Plate.* For butt joints in plate the operator shall make for each process and position one test weld in the maximum thickness of material for which he is to be qualified except that the thickness shall not exceed that permitted for the particular class of vessels under construction.

UA-43. *Welding Procedure.* The welding procedure shall comply in all respects with the Process Specification.

UA-44. *Test Specimens, Number, Type, and Preparation. Butt Welded Joints.* From each test weld there shall be taken the following test specimens which shall be prepared for testing as shown in the figures referred to:

For single-welded butt joints in plate: One face-break specimen, Fig. UA-9; one root-break specimen, Fig. UA-9; one side-break specimen, Fig. UA-10.

For double-welded butt joints in plate: Two face-break specimens, Fig. UA-16; one side-break specimen, Fig. UA-10.

UA-45. *Method of Testing Specimens. a Face-Break Test Specimens.* The specimen shall be supported and pressure applied as shown in Fig. UA-13, except that the face of the weld shall be opposite the side upon which pressure is applied. For double-welded butt joints one specimen shall be tested with one face down and the other specimen with the opposite face down.

If fracture of the specimen does not occur using the method shown in Fig. UA-13, the specimen shall be removed from the fixture and pressure shall then be applied to the specimen in the direction *AA* until fracture occurs or the specimen is bent flat upon itself. The surfaces of the fracture shall be examined for lack of soundness.

b Root-Break Specimens. The specimen shall be supported and pressure applied as shown in Fig. UA-13. The root of the weld shall be opposite the side upon which pressure is applied. If fracture of the specimen does not occur using the method shown in Fig. UA-13, the specimen shall be removed from the fixture shown and pressure shall then be applied to the specimen in the direction *AA* until fracture occurs or the specimen is bent flat upon itself. The surfaces of the fracture shall be examined for lack of soundness.

c Side-Break Specimens. The specimen shall be supported and pressure applied as shown in Fig. UA-14. If fracture of the specimen does not occur using the method shown in Fig. UA-14, the specimen shall be removed from the fixture shown and pressure shall then be applied to the specimen in the direction *AA* until fracture occurs or the specimen is bent flat upon itself. The surfaces of the fracture shall be examined for lack of soundness.

UA-46. *Retests.* In case an operator fails to meet the requirements on one or more test welds a retest may be allowed under the following conditions:

(1) An immediate retest may be made which shall consist of two test welds of each type on which he failed, all of which shall meet all the requirements specified for such welds.

(2) A retest may be made after the lapse of one week provided there is evidence that the operator has had further training or practice. In this case only one set of test welds of each type on which he failed need be made

[6] Fig. 15 of A.W.S. Tentative Rules for Qualification of Welding Processes and Testing of Welding Operators.

[7] Fig. 16, Ibid.

[8] Fig. 17 of A.W.S. Tentative Rules for Qualification of Welding Processes and Testing of Welding Operators.

[9] Fig. 18, Ibid.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Thermodynamics for Engineers

THERMODYNAMICS FOR ENGINEERS. By Henry F. Gauss. Edwards Brothers, Inc., Ann Arbor, Mich., 1936. Cloth, $8^{1}/_{4} \times 10^{3}/_{4}$ in., 426 pp., 114 figs., and 40 tables, $6.30.

REVIEWED BY B. H. JENNINGS[1]

THIS book presents the usual material covered in a textbook of engineering thermodynamics with emphasis on applications. These are rather heterogeneous, ranging from a description of certain domestic refrigerators to a detailed discussion of a method, employed by the author, for testing fans.

The book is lithoprinted with two columns per page and has a wealth of sketches and diagrams. The reproduction is clear and legible, and the book is really one of the best the reviewer has ever seen made by this method. Except for the large page size, it is as convenient as any printed book.

The author's proofs and derivations are sometimes rather long, and in many cases, a solution could be obtained by more direct methods. He has employed the temperature-entropy diagram to a much greater extent than the enthalpy-entropy diagram, even where the latter perhaps, could be employed to advantage. Marks and Davis' steam tables are used for reference in the steam work, and Keyes and Brownlee's, and Goodenough's values are used for ammonia. These choices seem unusual in light of more recent tabulations in both fields. No mention is made of the convenient pressure-enthalpy diagram in the work on refrigeration.

The book contributes little that is new to the field either in subject matter or method of presentation. However, much of the work is well-presented, particularly the applications, and a number of convenient curves and charts for quick solution of problems might make the book of value to practicing engineers for quick solution of problems. In one of the appendixes, a detailed analysis of boiler heat balances with many charts for quick determination of losses is presented.

Illustrative problems are carefully worked at various points in the text, and some problems for solution are also available. The tabulations of data and constants are well-selected.

[1] Associate Professor of Mechanical Engineering, Lehigh University, Bethlehem, Pa. Mem. A.S.M.E.

Alloys of Iron and Carbon

ALLOYS OF IRON RESEARCH MONOGRAPH SERIES. Vol. II, Properties. By F. T. Sisco. Published for the Engineering Foundation by the McGraw-Hill Book Company, Inc., New York and London, 1937. Cloth, 6×9 in., 777 pp., illus., diagrams, charts, tables, $8.

REVIEWED BY NORMAN L. MOCHEL[2]

THIS monograph is the eighth, in order of publication, of the Alloys of Iron Research Monograph Series. A list of the volumes previously published, a brief description of these monographs, and some general comments relative to their value were given in a previous review.[3]

The monograph under review is the second portion of a correlation and summary of what the world knows and believes in the matter of iron-carbon alloys. Volume 1 dealt with constitution and heat-treatment; volume 2 deals with the properties of iron-carbon alloys. It has been in preparation over a period of six years.

The following quotation from the author's preface will convey the tremendous task involved in the preparation of this monograph:

> The primary object of Alloys of Iron Research is to prepare monographs which are comprehensive critical summaries of the world's research on iron and its alloys and which should, necessarily, contain a discussion of all important available data. This postulates that the literature be thoroughly reviewed and that nothing of importance be omitted from the bibliography and from mention in the text. In the case of the present book this was impossible. The extent of the literature on the properties of plain carbon steels and cast irons is almost boundless. Even after rejecting from the thousands of published articles the direct duplications, condensations, and abstracts and the papers which restate previously reported facts in slightly different form, more than two thousand papers remained. Although these were reviewed in preparing the manuscript, it was impossible to include even all the important ones and still keep the book to a reasonable size.

The great importance of volume 1 on constitution and volume 2 on properties will be readily appreciated. The plain carbon steels and cast irons constitute the bulk of metals in use, and they are the most important commercial consideration. The constitution and properties of carbon steels and cast iron serve as a base line with which alloy steels may be compared. These two volumes, therefore, are of fundamental position in the series of monographs.

The subject matter is handled under seventeen general headings.

It is rather interesting, as developed in the opening chapter, that we do not have clear, well-defined, and accepted definitions of such terms as steel, iron, cast iron, etc. However, we appear to get along without them, without much trouble or disagreement.

The two sections dealing with cast steels give a rather complete discussion on this feature.

It is stated that about 97 per cent of all the steel made in the United States is cast into ingots and then processed into various finished or unfinished form by some type of hot working. It is estimated that only 6 or 7 per cent can be classed as alloy steel. Yet the author found relatively few data on the mechanical properties of hot-worked steels of varying carbon content. In other features also, there were too few data to permit broad generalization. There must be an unlimited number of results of tests in various laboratories in the country, but it is quite apparent that the subject is not one that stimulates technical writing. We apparently consider these matters to be rather commonplace. It is quite apparent that such subjects as cold working, heat-treatment, effect of mass, and grain size have been of more general interest.

The treatment of the subjects of manufacture and properties of cast iron and malleable cast iron is complete and arranged for ready reference.

[2] Metallurgical Engineer, South Philadelphia Works, Westinghouse Electric & Manufacturing Co., Lester, Philadelphia, Pa.

[3] Alloys of Iron and Carbon—Vol. I, Constitution, MECHANICAL ENGINEERING, March, 1937, pp. 200–201.

The behavior of iron-carbon alloys under repeated stresses (fatigue and corrosion fatigue), and under high-temperature conditions both regarding short-time and creep tests, and under conditions where corroding media are encountered, is dealt with at length.

The section on electric and magnetic properties will be of value to many, especially to those who meet with these considerations for the first time, and who have little time or opportunity to study the literature.

Those who are mainly interested in welding will not be satisfied with the short nine-page treatment of this important subject. The author, however, explains the difficulty that he faced, and the reasons for his treating the subject so briefly.

An excellent bibliography listing 822 references between the years of 1880 and 1935, a names index listing the authors of all references, and a carefully prepared index have been provided.

It is a volume that all who are technically interested in the preparation and use of steel should have available for reference purposes.

Diesel-Electric Plants

DIESEL ELECTRIC PLANTS. By Edgar J. Kates. American Technical Society, Chicago, 1936. Cloth, $5^1/_2 \times 8^1/_4$ in., 181 pp., illustrations, diagrams, charts, and tables, $2.

REVIEWED BY F. G. HECHLER[4]

UNQUESTIONABLY, if we may judge by widespread public interest, the Diesel engine has "arrived." This newest of our prime movers has definitely caught the fancy of the public, and, everywhere, young men are clamoring to get in on the ground floor of what they believe is a new industry with unlimited opportunities. Undoubtedly, the tendency has been to paint these opportunities in too rosy colors. However, the rapid extension of the use of Diesels will undoubtedly continue for some time, and excellent opportunities will be available for those who are adequately prepared to cope with the problems presented.

Until the recent development of the automotive-type engine, the greatest use of the Diesel was for power generation in isolated plants. This application is becoming increasingly important as the merits of the Diesel for carrying the entire load, for peak loads, or for standby service are becoming better appreciated. Ability to start a cold Diesel and to have it carrying full load in less than one minute makes it ideally adapted for the last two services. Even public-utility companies using steam or hydraulic turbines for most of their power are finding the Diesel useful for extensions into remote or sparsely settled sections, either to carry the load temporarily until it increases to a point that warrants building a transmission line or to act as a feeder at the end of a long line to prevent excessive line drop. Railroads have also found that Diesel-electric locomotives are helpful in regaining some of their lost traffic, and, of all the great nations of the world, the United States alone continues to build more steam-turbine than Diesel-powered ships.

In many cases, proper choice of a unit for a particular application can be made only after careful study by a competent engineer with a broad knowledge of all factors involved. For these reasons, Mr. Kates' book, which deals exclusively with Diesel-electric plants, is timely.

The Diesel engine itself is accorded only a few introductory pages, in which its general operating and performance characteristics are described, and data indicating probable operating costs given. The remainder of the book is devoted to a detailed discussion of electrical equipment to be used in the plant and how the characteristics of the Diesel engine influence its selection.

Voltage regulation, both direct and alternating-current, is an important subject and one on which published information has, heretofore, been meager. Various types of commercial regulator are fully described and their performance explained. Parallel operation of Diesel-driven generators is treated in a practical manner, starting with a brief explanation of the fundamental principles, and proceeding to methods of, and instruments for, synchronizing, checking phase sequence, adjustment of field current, and the like. Diesel-engine governors and how they function in controlling frequency and load distribution for parallel operation are fully described. The definition of terms used with governors should be helpful to the average reader.

In defining speed drop in per cent, the author departs from accepted practice and divides the change in speed by the no-load speed instead of by the mean speed. Semi- and full-automatic operation of Diesel generating units, both singly and in multiple, is of so much interest that a short chapter has been wisely given to a discussion of the problems involved and to the equipment used to insure dependable performance. Routine procedure for putting Diesel-driven generators and voltage regulators of various kinds in and out of service is brought together in concise form. Automatic electrical devices for controlling and safeguarding the operation of the engine itself are described and illustrated.

Fundamentals of Diesel-electric railroad applications are discussed briefly with the aid of schematic diagrams. The last chapter is devoted to the installation of electrical equipment, its operating care and adjustments, and trouble shooting.

Mr. Kates has performed a useful service in bringing together and correlating the data on Diesel-electric plants. His own wide experience as a Diesel engineer and consultant qualifies him for the task. Designers, operators, superintendents, and owners of Diesel-electric power equipment will welcome the book because of its clear exposition of the principles involved and the descriptions of the present commercially available equipment.

[4] Director, Engineering Experiment Station, The Pennsylvania State College, State College, Pa. Mem. A.S.M.E.

Books Received in Library

FREEZING PRESERVATION OF FRUITS, FRUIT JUICES, AND VEGETABLES. By D. K. Tressler and C. F. Evers. Avi Publishing Co., New York, 1936. Cloth, 5×8 in., 369 pp., illus., diagrams, charts, tables, $5. This monograph provides a useful compendium of information upon a subject of growing importance. The broad principles of the selection of raw materials of the proper variety, and their preparation, freezing, storage, handling, and preservation for the table are discussed. Each chapter has a bibliography. The book will be useful to all interested in food preservation.

KNITTING FULL-FASHIONED HOSIERY. By M. C. Miller. McGraw-Hill Book Co., New York and London, 1937. Cloth, 6×9 in., 259 pp., illus., diagrams, charts, tables, $5. This book gives a complete, detailed description of the flat full-fashioned knitting machine, and of the methods of operating it. It claims to be the only book in English on the subject.

KRAFTFAHRTECHNISCHE FORSCHUNGSARBEITEN, Heft 5. V.D.I. Verlag, Berlin, 1936. Paper, 8×12 in., 21 pp., illus., diagrams, charts, tables, 3.50 rm. Contains reports of investigations of three automobile problems. The first describes tests of the bending vibrations in the three-bearing crankshaft of a four-cylinder Diesel automobile engine. The remaining two deal with investigations of scavenging in two-cycle engines, undertaken for the purpose of reducing the fuel consumption of this type.

KUNST- UND PRESSSTOFFE. I. V.D.I. Verlag, Berlin, 1937. Paper, 8×12 in., 38 pp., illus., diagrams, charts, tables, 2.75 rm. This brochure is the first of a series to be issued under the auspices of the Plastic and Pressed-Materials Section of the Verein deutscher Ingenieure, which will be devoted to information upon these substances. Some fifteen papers are included, discussing the chemistry of synthetic resins, the use of pressed materials in

building, synthetic-resin bearings, domestic uses of plastics, and other matters.

MACHINE SHOP OPERATIONS. By J. W. Barritt. American Technical Society, Chicago, 1937. Leather, 8 × 11 in., 850 pp., illus., diagrams, charts, tables, $5. This volume contains detailed descriptions of 280 jobs which are typical of major operations which a skilled mechanic is called upon to do. The jobs cover the lathe, milling machine, slotter, horizontal boring mill, shaper, drill press, planer, vertical boring mill, measuring tools, bench work, floor work, and layout work. The directions are clear and definite and the book is an excellent text for students and apprentices.

MAKING AND MOLDING OF PLASTICS. By L. M. T. Bell. Chemical Publishing Co., New York, 1936. Cloth, 6 × 9 in., 238 pp., illus., diagrams, charts, tables, $5. The aim of the author "has been to provide a simply written book in which the history, the present-day essentials, and the probable future developments of plastic moldings are discussed." He has "also included some discussion of processes of resinification." The more important materials and processes are described, with chapters on plant and equipment, mold design and construction, and inspection and testing.

MANAGING FOR PROFIT. By C. E. Knoeppel with the collaboration of E. G. Seybold. McGraw-Hill Book Co., New York and London, 1937. Cloth, 6 × 9 in., 343 pp., illus., diagrams, charts, tables, $3.50. This volume discusses working methods for profit planning and control. Recently developed aids to management in the way of profit-making tools and methods are described, the ways that they work are illustrated, and their application to better the profit position of a business is explained.

(The) MANUFACTURE OF PULP AND PAPER. Vol. 3. Third edition. Edited by the Joint Executive Committee on Vocational Education Representing the Pulp and Paper Industry of the United States and Canada. McGraw-Hill Book Co., New York and London, 1937. Cloth, 6 × 9 in., 818 pp., illus., diagrams, charts, tables, $6.50. The preparation and treatment of wood pulp is discussed comprehensively in this work, which claims to be the most complete discussion of the subject in any language. The work has the endorsement of the principal trade associations. This edition has been thoroughly revised and in part rewritten, in the light of recent developments.

MATERIALS HANDBOOK. By G. S. Brady. Third edition. McGraw-Hill Book Co., New York and London, 1937. Leather, 4 × 7 in., 661 pp., diagrams, charts, tables, $5. A concise, encyclopedic reference book for the identification of the multitudinous materials used in industry. Information is given as to physical and chemical properties, constitution, and uses. The materials vary from basic raw materials, such as mineral ores and woods, to such things as alloy steels and artificial insulating compounds. The appendix contains numerous useful tables. Intended primarily for purchasing agents and industrial executives, its field is much wider as a reference tool.

MATHEMATICAL RECREATIONS AND ESSAYS. By W. W. R. Ball. Tenth edition. Macmillan & Co., London and New York, 1931. Cloth, 5 × 8 in., 366 pp., diagrams, charts, tables, $3.50. This is a reprint of an amusing little book which has run through ten editions. It covers arithmetical, geometrical and mechanical problems, magic squares, and chess and playing-card recreations. There are also discussions of cryptographs, ciphers, and various famous calculating prodigies. From the later editions a good deal of historical information has been omitted which was included in the earlier ones.

MATTHEW BOULTON. By H. W. Dickinson. University Press, Cambridge, England; Macmillan Co., New York, 1937. Cloth, 6 × 10 in., 218 pp., illus., maps, tables, $4.50. Mr. Dickinson has made a thorough study of the available material, published and unpublished, on Boulton and his work. His account of the life and activities of the great captain of industry is accurate and readable, a valuable memorial of an important man. It is the first separate biography of Boulton published.

MEN OF MATHEMATICS. By E. T. Bell. Simon and Schuster, New York, 1937. Cloth, 6 × 10 in., 592 pp., illus., diagrams, charts, tables, $5. Biographical and critical information about the important men in the mathematical field, from the Greeks to the present time, who have contrived, explored, or expanded the concepts which are the basis for the modern physical sciences. Relatively simple examples of their work are used to illustrate the direction and scope of their researches.

MITTEILUNGEN AUS DEN FORSCHUNGSANSTALTEN GHH-KONZERN, Band 5, Heft 1, January, 1937. V.D.I. Verlag, Berlin, 1937. Paper, 8 × 12 in., illus., diagrams, charts, tables, 2.70 rm. In this number Dr. Juenger discusses "increasing the resistance of steel to sea-water corrosion and bending by surface compression, nitriding, case hardening, and galvanizing." In a second paper, Gustav Mussgnug gives the results of an investigation of the "influence of the burning temperature upon the properties of cement."

MITTEILUNGEN DER MATERIALPRÜFUNGSANSTALT AN DER TECHNISCHEN HOCHSCHULE DARMSTADT, Heft 9. KORROSION UND DAUERFESTIGKEIT, by A. Thum and H. Ochs. V.D.I. Verlag, Berlin, 1937. Paper, 6 × 9 in., 109 pp., illus., charts, tables, 9 rm. This report discusses the influence of corrosive surroundings upon the endurance of materials under stress. The results of all previous researches have been tabulated and supplemented by new investigations. In addition the phenomena of corrosion fatigue are explained and the possibilities of increasing the resistance to corrosion discussed.

NATIONAL ASSOCIATION OF RAILROAD AND UTILITIES COMMISSIONERS. PROCEEDINGS OF 48TH ANNUAL CONVENTION, held at Atlantic City, N. J., November 10 to 13, 1936. State Law Reporting Co., New York. Cloth, 6 × 9 in., 541 pp., tables, $6. The report contains the discussions on the topics set for this meeting, viz., uniform systems of accounts for gas and electric companies, the operation of the federal motor carrier act, the regulation of electric utilities and of telephone companies, progress in public-utility regulation and public-utility rates. A list of members and committees is included.

OIL: Stabilization or Conservation. By M. W. Watkins. Harper & Brothers, New York and London, 1937. Cloth, 6 × 10 in., 269 pp., tables, charts, $3.50. This book which originated in a study of the working of the NRA code in petroleum, is a study of the basic operating problems of the oil industry. It presents an analysis of these questions with particular reference to the problems of public control of production and distribution which reviews the entire subject in a thorough, up-to-date way.

Österreichisches Petroleum-Institut (Ö.P.I.-Veröffentlichung No. 7). ERDÖL-UNTERSUCHUNGSMENTHODEN, Folge 1. Edited by E. Molnar. Verlag für Fachliteratur Ges., Vienna, 1937. Paper, 6 × 8 in., 168 pp., tables, 10 rm. This publication presents the methods of testing gasoline, kerosene, gas and fuel oil, and machine oil used in 22 countries. The methods are tabulated, so that comparison is easy, and are described with sufficient fullness for ordinary purposes. References to sources of detailed information are given, and there is a bibliography of standards in various countries.

ÖSTERREICHISCHES PETROLEUM - INSTITUT (O.P.I. Veröeffentlichung 6). Über die LENKBARKEIT DER MOTORISCHEN VERBRENNUNG. By W. Ostwald. Verlag für Fachliteratur Ges., Vienna, 1937. Paper, 6 × 8 in., 35 pp., illus., diagrams, charts, 2 rm. This pamphlet contains a lecture delivered before the Austrian Petroleum Institute. The various questions of combustion in internal-combustion engines are discussed, it being pointed out that actual engines are compromises between the maximum theoretical thermal efficiency and other factors. The advantages of various engines are considered, and attention is given to some recent developments.

PETROLEUM PRODUCTION. By W. F. Cloud. University of Oklahoma Press, Norman, Okla., 1937. Cloth, 6 × 10 in., 613 pp., illus., diagrams, charts, tables, $5. Although essentially a practical treatment of the subject, the material is necessarily general because of the great number of special problems met in the various oil fields. Geological problems and the drilling process itself are not discussed except in particular cases. Legal matters in connection with acquiring rights are considered. The production information covers both oil and natural gas, including equipment and methods, preparing and shipping crude oil, water problems, and storage facilities.

REAUMUR. Edited by J. Torlais. Desclée de Brouwer et Cie., Paris, 1936. Paper, 5 × 8 in., 447 pp., illus., 20 fr. This is said to be the first extended biography of the great French scientist. Best known today for his thermometer, his activities covered many fields. He contributed to the art of making steel, tin plate, and porcelain. His work in the fields of entomology and physiology was notable. The book gives a good account of the man and his varied activities, with an extensive bibliography.

RECOLLECTIONS AND REFLECTIONS. By J. J. Thomson. Macmillan Co., New York, 1937. Cloth, 6 × 10 in., 451 pp., illus., diagrams, $4. A famous physicist reminisces on many things. The material is mainly autobiographical, covering school and college days, first experimental work, visits to various countries and psychical research. Later chapters contain sketches of contemporaries and lucid descriptions of certain important developments in the field of physics in which he had a part or which came within his time.

REFRIGERATING DATA BOOK, Third edition. American Society of Refrigerating Engineers, New York, 1936. Cloth, 6 × 9 in., 519 pp., illus., diagrams, charts, tables, $4. A com-

pilation of information on refrigerating, heat and power engineering, air conditioning and domestic-commercial refrigeration. In addition to a large amount of technical data on the theory and operation of equipment in these fields there are sections on statistics, a refrigerating glossary, conversion data, a brief catalog of manufacturers, and a list of members of the American Society of Refrigerating Engineers.

REGELN FÜR DIE DURCHFLUSSMESSUNG MIT GENORMTEN DÜSEN UND BLENDEN. V.D.I.-Durchfluss-Messregeln DIN, 1952. V.D.I. Verlag, Berlin, 1937. Paper, 8 × 12 in., 23 pp., diagrams, charts, tables, 5 rm. A new edition of the standards for the measurement of fluid flow by means of orifices and nozzles. A few changes in the rules appear and certain additions are made.

Report on the IMPORT DUTIES ACT INQUIRY (1934) 2 Parts. Part 1: Textile Trades, the Leather and Clothing Trades, the Food Trades the Chemical and Allied Trades, Miscellaneous Trades; 386 pp., $1.75. Part 2: Iron and Steel Trades, the Engineering and Vehicle Trades, the Non-Ferrous Metals Trades, the Timber, Paper, Clay and Building Materials Trades; 308 pp., $1.40. His Majesty's Stationery Office, London, 1937. Paper, 6 × 10 in., tables. Obtainable from British Library of Information, New York. Statistical information for Great Britain on various trades, covering the year 1934. These statistics were gathered by the British Board of Trade and cover gross and net output (monetary values), employment, and net output (value) per person employed. A final summary compares the figures for 1934, 1933, and 1930.

REPORTS ON PROGRESS IN PHYSICS, vol. 3. Edited by A. Ferguson. Published by the Physical Society, London, at University Press, Cambridge, 1937. Cloth, 7 × 10 in., 394 pp., illus., diagrams, charts, tables, 20 s. This useful annual provides a review of the advances in physics during 1935. The reviews, each prepared by an authority, are accompanied by bibliographies. The subjects covered are: general physics, fluid motion, the upper atmosphere, atomic physics, the conservation of energy and momentum in elementary processes, sound, the measurement of noise, heat, magnetism, experimental electricity and magnetism, electrical methods of counting, superconductivity and the theory of metals, photoelectricity, optics, X-rays, and spectroscopy.

STEAM BOILERS. By T. Croft, revised by R. B. Purdy. Second edition, McGraw-Hill Book Co., New York and London, 1937. Cloth, 6 × 8 in., 417 pp., illus., diagrams, charts, tables, $4. This second edition has been much revised in the light of modern practice. It is still primarily for "men of little schooling." The material covers functions of boilers, construction and inspection, accessories, steam generation and superheating, boiler capacities, ratings, and economy, and the selection of boilers. Questions and problems aid in mastering the information presented.

STEAM POWER AND INTERNAL COMBUSTION ENGINES. By D. P. Craig and H. J. Anderson. McGraw-Hill Book Co., New York and London, 1931. Cloth, 6 × 9 in., 482 pp., illus., diagrams, charts, tables, $4.50. Primarily a textbook for engineering students on the fundamental principles underlying heat-power machinery, there is as well information of value to engineers in practice. In general, electrical equipment has been omitted from consideration, the subjects covered including fuels (combustion and handling), boilers, superheaters, feedwater, steam engines and turbines, condensing and pumping equipment, and internal-combustion engines.

STEAM POWER STATIONS. By G. A. Gaffert. McGraw-Hill Book Co., New York and London, 1937. Cloth, 6 × 9 in., 559 pp., illus., diagrams, charts, tables, $4.50. Here is a comprehensive book covering the multitudinous phases of steam-power-station work. The earlier chapters cover the mechanical equipment: prime movers, condensers, boilers and their auxiliaries, piping, coal and ash handling and pumping equipment. Within this group is found also the consideration of fuels and feedwater. The succeeding chapters deal with what may be called plant economy: costs, location, selection of equipment, and station design. There is also included a chapter on binary vapor cycles. Problems and short bibliographies increase the value of the book.

STEAM TURBINE OPERATION. By W. J. Kearton. Second edition. Sir Isaac Pitman & Sons Ltd., London; Pitman Publishing Corporation, New York, 1936. Cloth, 6 × 9 in., 346 pp., illus., diagrams, charts, tables, $3.75. Here is an eminently practical presentation of the operating side of steam-turbine engineering. It covers thoroughly the installation, starting and stopping, lubrication, inspection and overhauling, and testing of steam turbines as problems met in actual operation. Enough descriptive material concerning turbine principles and accessories is included to clarify instructions fully. To this second edition have been added new chapters on regenerative feed heating and blade erosion.

SYMPOSIUM ON RADIOGRAPHY AND X-RAY DIFFRACTION METHODS, held at the 39th Annual Meeting of the American Society for Testing Materials, Atlantic City, N. J., June 30-July 1, 1936. American Society for Testing Materials, Philadelphia, 1937. Cloth, 6 × 9 in., 350 pp., illus., diagrams, charts, tables, $4. A collection of papers upon the ways in which X-rays and gamma rays may be used for testing materials, which were presented at a symposium held by the Society in 1936. The book provides a concise, critical account of the available methods, compares them critically with other methods and suggests future developments.

LA TECHNIQUE DE L'ORGANISATION DES ENTREPRISES. Vol. 1. Le Gouvernement de l'Entreprise. By J. Chevalier. Third edition. Dunod, Paris, 1937. Paper, 7 × 10 in., 197 pp., illus., 39.20 fr. A presentation of the principles of scientific management as applied to the organization and operation of industrial enterprises. Administrative, financial, technical, economic, and social problems are considered.

LA TECHNIQUE DE L'ORGANISATION DES ENTREPRISES. Vol. 2. L'Organisation du Travail. By J. Chevalier. Third edition; Dunod, Paris, 1937. Leather and paper, 7 × 10 in., 233 pp., illus., diagrams, charts, tables; paper, 35 fr., bound, 50 fr. This volume on factory organization deals with the direct technical questions involved. The organization of work and the physiological conditions for working, standardization, time study, task setting, the selection of employees, wage systems, and plant organization are discussed.

TOLERANZEN UND LEHREN. By P. Leinweber. Julius Springer, Berlin, 1937. Paper, 6 × 9 in., 115 pp., illus., diagrams, charts, tables, 6.60 rm. This book aims to provide the draftsman and designer with a knowledge of tolerances and gages which will enable them to make proper designs and shop drawings for mass production. The principles of tolerances are explained and their application described. The varieties of gages and their uses are discussed, with brief notes on their correct design.

(The) TRUTH CONCERNING THE INVENTION OF PHOTOGRAPHY. NICEPHORE NIEPCE, His Life, Letters, and Works. By V. Fouque, translated by E. Epstean. Tennant and Ward, New York, 1935. Cloth, 5 × 7 in., 163 pp., $5. This work, published in Paris in 1867, was written to vindicate the claim of Niépce to the invention of photography. Based upon his letters and other unpublished documents, it describes his experiments, his partnership with Daguerre, and his death. The book is an important contribution to the history of photography, now made accessible to English readers.

(The) UNDISTRIBUTED PROFITS TAX. By A. G. Buehler. McGraw-Hill Book Co., New York and London, 1937. Cloth, 6 × 9 in., 281 pp., tables, $2.75. A study of the undistributed profits tax, dealing chiefly with the main provisions of the new tax law, the historical background of the tax, and its economic and fiscal implications. The effects of the tax on corporation dividend policies, corporation financing, stockholders, bondholders, large and small corporations, and general business conditions are considered. The tax also is examined in the light of fiscal principles, and desirable reforms are suggested.

L'UBICAZIONE DEGLI IMPIANTI INDUSTRIALI. By F. Mauro. Third edition. Enios, Rome, 1936. Cloth, 7 × 10 in., 175 pp., maps, diagrams, 15 lire. A broad discussion of the question of factory loaction is provided in this book. The importance of accessibility to raw materials, markets, transportation lines, and sources of energy is discussed. Accessory and special conditions are considered, and general conclusions drawn. This edition is revised and enlarged.

WATERWAY ENGINEERING, a Text and Handbook Treating of the Design, Construction, and Maintenance of Navigable Waterways. By O. Franzius, translated by L. G. Straub. Technology Press, Massachusetts Institute of Technology, Cambridge, 1936. Cloth, 6 × 10 in., 527 pp., illus., diagrams, charts, maps, tables, $7. This translation of "Der Verkehrswasserbau" is a valuable addition to the small number of books in English on the subject. River control, river mouths and their treatment, the effect of the sea on coasts, seashore development and levee construction, weirs, ship locks and artificial waterways are discussed from the viewpoint of designer and constructor in a practical way. The book affords a comprehensive account of good European practice.

V.D.I. Jahrbuch, 1937. Die Chronik der Technik. Edited by A. Leitner. V.D.I. Verlag, Berlin, 1937. Paper, 6 × 8 in., 228 pp., 3.50 rm. The "Yearbook" provides a concise annual review of outstanding developments in the engineering field, enabling the user to survey rapidly the chief achievements in all branches. Some eighty brief surveys are included, with references to over 7000 sources of more detailed information. A lengthy index is included.

THIS MONTH'S AUTHORS *and* PAPERS

CARRYING the maximum number of passengers between terminals with the least cost was the railroad's only problem in the earlier days. Automobiles and airplanes have influenced both the commercial and the engineering, or manufacturing, side of the railroad business, the results being better-appearing and lighter-weight cars, elimination of noise, and quicker acceleration and braking. Specific examples of this influence are presented in the paper by E. G. BUDD, entitled "Automotive Engineering Applied to Railroading." Reduction in airplane and automobile weight has been accomplished by using alloy steels having strength and fatigue resistance many times those of the mild steels formerly in general use. These steels could not, because of the size of the structure, be used in railroad cars, and a search by the development department of the Budd organization showed that an alloy steel containing 18 per cent of chromium and 8 per cent of nickel best met the requirements of this service.

Mr. Budd, who first advocated and first manufactured all-steel automobile bodies and more recently developed the use of light-weight stainless steel in the construction of trains, airplanes, and boats, has been interested in sheet metal forming ever since 1900, when, as shop superintendent for the American Pulley Company, he designed the first sheet-metal pulleys ever used. The first all-steel automobile bodies were built under his supervision at the Hale & Kilburn plant in 1910, and, two years later, he formed the Edward G. Budd Mfg. Company to produce sheet-metal stampings. The company gradually developed automobile parts and, finally, completed bodies. About 1930, Mr. Budd's interest was attracted by the physical properties of stainless steel, and, after four years of research and experimentation, he entered a new field of endeavor, the use of these new high physical strength noncorrosive steels where light weight is of value, which has led to their incorporation in high-speed railroad development.

MACHINE TOOLS AND AUTOMOBILES

Ever-changing demands by automobile builders have been the primary incentive for changes and improvements made in machine-tool design and construction during the last several years, and these improvements have benefited all industries using machine tools. These improvements are not revolutionary but are gradual and in keeping with the annual refinements developed by the automotive industry. Numerous examples of how the demands of the automotive industry have been met by the machine-tool builders are presented in the paper by F. W. CEDERLEAF entitled "Machine-Tool Builders' Contributions to Mass Production of Automobiles."

The author has been associated with one branch or another of the automotive industry for approximately 20 years in positions that afforded ample opportunity to know the latest developments in machinery and machine tools. From 1917 to 1924, he was associated with various automobile and parts manufacturers, and, for the next 11 years, he was connected with several divisions of the General Motors Corporation in various capacities. Since 1935, he has been manager, machinery division, Ex-Cell-O Aircraft & Tool Corporation, Detroit, Mich.

RAILROAD APPLICATIONS OF WELDED STEEL

Light weight and high fatigue strength are required in high-speed railroad service, and welded alloy steels have met these demands. Sculpturing corners and contours and easing boundary conditions where a change of direction is involved call for great care and attention, and selection of proper structural shapes to transmit the imposed load to its reaction as directly as possible requires considerable thought. Steel and heat in combination can produce unbelievable results, and one of the greatest hazards in using welded-steel structures is the possibility that cracks which develop while the piece is being welded, will not be discovered before the finished structure is placed in use. These and many other similar thoughts are contained in the paper by EVERETT CHAPMAN entitled "Welded Steel in High-Speed Railroad Service."

The author, who is an A.S.M.E. member and president of Lukenweld, Inc., is qualified by education and experience to discuss this topic. At the University of Michigan, from which he received the degrees of B.S. and M.S., Mr. Chapman specialized in the design of welded-steel structures. A year at Purdue University as an instructor in electrical engineering was followed by four years, 1925–1929, with the Lincoln Electric Company as research engineer in welding and the development of electrical control. In 1929, he became director of engineering and research at Lukenweld, Inc., supervising design and development.

EFFECTIVE USE OF METAL-CUTTING TOOLS

Proper selection of tool material, heat-treatment methods, and nose contour when correctly correlated with rate of feed, depth of cut, material machined, tool life under cut, and cutting speed will effect marked savings in tool costs. This conclusion is drawn by R. C. DEALE in his paper "Effective Use of Metal-Cutting Tools," which presents a résumé of studies and experiments carried on by the Subcommittee on Metal-Cutting Data of the A.S.M.E. Special Research Committee on Cutting of Metals.

As a result of this work, formulas have been developed for cutting speed, power required to remove chips of a definite thickness, and the interval at which tools should be reground to give minimum cost of machining, and standard practice has been established for other factors that are not susceptable of mathematical analysis.

Mr. Deale, who is an A.S.M.E. member, is supervisor of tools and apprentices at the Brooklyn, N. Y., plant of the E. W. Bliss Company, While with the Niles-Bement-Pond Company, as assistant chief engineer and chief electrical engineer, he developed various standard types of machine tools and the electrical controllers and control systems associated with them. Mr. Deale has had considerable experience as a plant management consultant, principally in machine shops, and devoted four years to a study of cutting of metals and preparation of manuscript for a manual on this subject which will shortly be issued by the A.S.M.E. Special Research Committee on Cutting of Metals.

HUMANISTIC STUDIES IN ENGINEER'S TRAINING

At a joint luncheon of personnel officers and engineers representing several learned societies, held in connection with the 1936 A.S.M.E. Annual Meeting, a reporter from the *New York Times* picked up an informal address by J. W. ROE for his paper. His brief account brought many letters to Professor Roe containing requests for a copy of his remarks, and as a result the little article "Humanistic Subjects in the Engineer's Training" was prepared for publication in MECHANICAL ENGINEERING.

Joe Roe, as he is affectionately called by former students and friends in the engineering world, has served industry, education, and the government throughout his career. A teacher in whose classes none could be a dullard if he would, Professor Roe has enlivened audiences and groups of friends as well as students by his insight into the nontechnical influences that have been brought to bear on engineering. He has written extensively on the history of engineering and industry and on the biography of engineers and industrialists. His biography of James Hartness is soon to be published by The American Society of Mechanical Engineers. Student of machine design, machine tools, and problems of machine production, production technique, and industrial management, he made these subjects alive to young men at Yale and at New York University. He has served the A.S.M.E. for more than a quarter of a century as a loyal member, author of papers, and committeeman. Retiring from New York University this year he will serve during the coming academic year as a visiting professor at Yale, his alma mater and scene of his early teaching career.

LUBRICANTS AND FALSE BRINELLING OF BEARINGS

Automobiles will travel tens of thousands of miles without measurable wear of their anti-friction bearings, despite rough usage from high speed, overloading, and infrequent lubrication and yet these same ball and roller bearings are often seriously damaged while the vehicle is being shipped in freight cars and on trucks. As this damage consists of indentations in the raceways on the loaded side of the bearings opposite each ball or roller which appear to have been produced by extremely high pressures, the term "brinelling" is erroneously used to describe this condition. Since this damage may occur under load conditions that are far too low to cause true brinelling it clearly is not a case of pressure indentation but a form of bearing wear.

An investigation of numerous examples of bearings indentation by the research laboratories section of the General Motors Corpora-

tion showed that distance, season of the year, and method of loading automobiles in freight cars all influenced the degree of damage. The paper "Lubricants and False Brinelling of Ball and Roller Bearings" describes a laboratory-test machine that was constructed to permit wide variation in load, speed of operation, amplitude of vibration, and temperature as a result of this investigation and a number of tests of bearings that were made with it. Based on these tests, J. O. ALMEN author of the paper and head of the dynamics department of the research laboratories section, states that the indentations are not brinelling but a form of wear which is dependent on, or aggravated by, the presence of oxygen. If air is excluded from the region of contact between races and balls or rollers, the situation cannot become serious, and low-viscosity lubricants will greatly reduce this oxidation wear although their use will not completely eliminate it.

ADEQUATE OPERATING INSTRUCTIONS

While designers and builders of equipment usually are anxious to share the responsibility of developing effective operating instructions because competition compels them to see that operation after sales is satisfactory, the final responsibility for the development of such instructions and their enforcement clearly rests with the owner of the equipment and the supervisor in charge of its operation. In the paper "Engineering Value of Adequate Operating Instructions," D. L. ROYER points out that, to be effective, operating instructions must be correct, complete, and easily understood; should be a matter of definite written record, and must be strictly enforced.

Mr. Royer's experience includes receiving instructions, such as he discusses in his paper, as well as their formulation and interpretation, since 1914 when he accepted a position as inspector in the Chicago office of the Ocean Accident and Guarantee Corporation. Four years later he came to New York as chief engineer of the Corporation, a position that he still holds, and, since 1927, he has also been manager of the boiler and machinery department. Mr. Royer is a member of the A.S.M.E.

PHOTOELASTIC MATERIALS

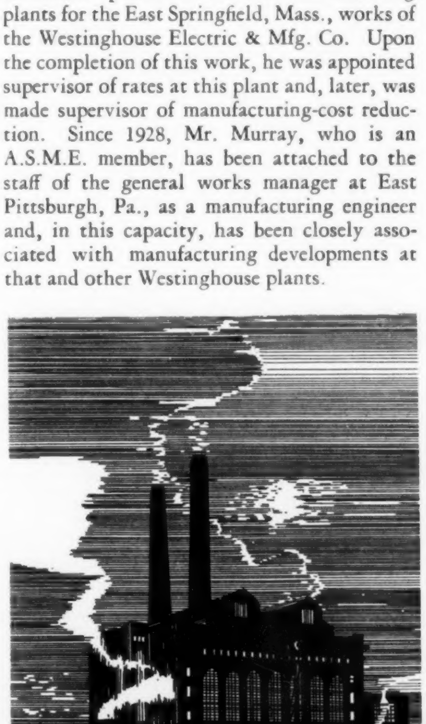
Early photoelastic investigations used glass models and evaluated the intensity of the stresses by a compensation method. Difficulties in the preparation of these models led to the substitution of celluloid, which, in turn, was replaced by materials of higher stress-optical sensitivity, such as bakelite, phenolite, marblette, and similar substances. These were satisfactory when the model was of a simple type and the load applied to determine the isoclinics was lower than that used for determining the monochromatics. To determine the direction of the stress from the isoclinics, A. G. SOLAKIAN advocates the use of a material having a low stress-optical sensitivity, such as plexiglas or the recently developed plastic, lucite (pontalite) in a contribution entitled "Stress-Optically Less Sensitive Materials in Photoelasticity."

Mr. Solakian is a native of Turkey and a graduate of Roberts College, Istanbul, where he taught structural engineering and materials testing from 1917 to 1930. After studying photoelasticity at University College, London, under E. G. Coker, Mr. Solakian came to this country and has been lecturing on this subject at Columbia University and also conducting research work.

MANUFACTURING LAYOUT ECONOMICS

Making a manufacturing layout involves much more than machine cutouts, map tacks, floor-plan boards, and pieces of string. In its broader aspects, it includes product design, process development, tools and machinery, building construction, operation analysis and sequence, production control, and similar topics. A. F. MURRAY's paper "Economics of Manufacturing Layout" tells the experiences of the Westinghouse organization in solving the problems presented by the manufacture of new products or changes in existing ones with particular reference to the machinery involved.

The author's experience includes time study, plant layout, equipment and maintenance, and sales engineering with Remington Arms, Elliott-Fisher, and Blake-Knowles companies before joining the New England Westinghouse Company in 1916. He was in charge of time study and rate setting for plants making Russian rifles and Browning machine guns for three years, and, after the cessation of World War hostilities, assisted in converting these munitions plants into motor-manufacturing plants for the East Springfield, Mass., works of the Westinghouse Electric & Mfg. Co. Upon the completion of this work, he was appointed supervisor of rates at this plant and, later, was made supervisor of manufacturing-cost reduction. Since 1928, Mr. Murray, who is an A.S.M.E. member, has been attached to the staff of the general works manager at East Pittsburgh, Pa., as a manufacturing engineer and, in this capacity, has been closely associated with manufacturing developments at that and other Westinghouse plants.



ANALYSIS OF FLUID FLOW

Distribution or pattern of fluid flow is of vital importance to engineers in many instances, but, heretofore, the apparatus for obtaining this information has generally been expensive, bulky, and difficult to operate. To overcome these obstacles, H. L. PARR designed and built an apparatus intended primarily to illustrate the principles of fluid dynamics to engineering students but also capable of wider application. The main feature of this equipment, which is described in the article entitled "Fluid-Flow Analyzer," is that smoke blows between two closely spaced plates, thus enabling considerable air velocities to be used and requiring little protection to maintain parallel flow. Photographs or motion pictures can be taken of the smoke lines.

The author, who received his education at Columbia University, has been connected with it practically ever since his graduation and has been in charge of the laboratories of the mechanical-engineering department there since 1907. In 1928, he was appointed professor of mechanical engineering and, in recent years, has specialized in fluid dynamics and given classroom and laboratory courses in this subject. Professor Parr has been a member of A.S.M.E. since 1910.

PROCESSING RESEARCH FOR AGRICULTURE

Eliminating waste and spoilage of perishable products, curing tobacco electrically, control of temperature and humidity in sweet-potato storage, improved methods of making and marketing sorghum, and processing of cotton and cottonseed are a few applications of research to agriculture which are described in the paper "Processing Research for Agriculture." How engineering can enlist for the conquest of the new frontier presented by agriculture, the place of the laboratory in industry of the future, and improvement of farm income by research on engineering problems especially those concerned with conserving and processing raw materials are described.

The author, J. P. FERRIS, was engaged for some years in coordinating the various agencies on land use in Wisconsin and the formulation of land-use programs and the coordination of the technical and economic research activities of that state with its industrial needs. For the last three years, he has been associated with the Tennessee Valley Authority as chief of the small industries section of the industrial division and, more recently, as acting director of the agricultural industries division. His work there has comprised investigations of manufacturing possibilities for the area, planning and interpreting economic studies, conduct of industrial decentralization studies, and formulation of plans for organizing and financing small privately owned plants.

THE "COMMON LAW" OF INDUSTRIAL RELATIONS

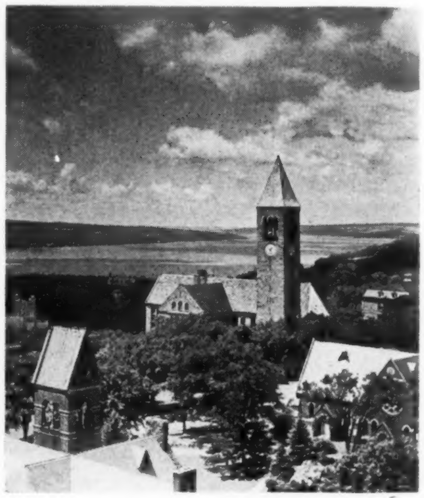
This month's review of economic literature "The 'Common Law' of Industrial Relations, from the Department of Economics and Social Science of the Massachusetts Institute of Technology, under the sponsorship of the A.S.M.E. Management Division, is by E. R. LIVERNASH, an assistant in economics at M.I.T.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

Applied Mechanics and Hydraulic Divisions to Hold Joint Meeting at Ithaca, N. Y., June 25–26

Final Program of Technical Papers and Sessions



"FAR ABOVE CAYUGA'S WATERS"

FINAL plans have now been made for the Fifth National Meeting of the Applied Mechanics Division of the A.S.M.E. which is to be held jointly with the Hydraulic Division at Ithaca, N. Y., June 25 and 26, under the auspices of Cornell University and the Ithaca Section of the Society.

Headquarters for the meeting will be at Willard Straight Hall where registration will be conducted and rooms in Balch Hall assigned. Morning sessions will start at 9 a.m. and afternoon sessions at 2 p.m.

Of the technical papers relating to vibration, two will deal with the use of rubber, one with engine crankshafts, and a fourth with the effects of earthquakes on buildings. Elasticity is the subject under discussion at one of the sessions, which is followed by another devoted to plasticity in metals and soils. The papers contributed by the Hydraulic Division are devoted to cavitation, the theory of turbulence, and flow through granular materials.

At the dinner on Saturday, with C. R. Soderberg acting as toastmaster, H. J. Gough, of the National Physical Laboratory, England, will present some notes on the work of that institution.

A detailed program of the technical sessions follows:

FRIDAY, JUNE 25

9:00 a.m. Vibration Session

Chairman: J. P. Den Hartog, Harvard University

The Use of Rubber in Vibration Isolation, by E. H. Hull, General Electric Company

Rubber Mountings, by J. F. Downie-Smith, E. G. Budd Company

The Crank Arrangement of a Nine-Cylinder Engine, by Frank M. Lewis, E. E. Breault, and R. M. Donaldson, Massachusetts Institute of Technology

Influence of Earthquakes Upon Buildings, by L. S. Jacobsen, Stanford University

9:00 a.m. Joint Session

Applied Mechanics and Hydraulic Divisions

Cochairmen: J. C. Hunsaker, Massachusetts Institute of Technology and F. G. Switzer, Cornell University

Cavitation Testing of Marine Propellers, by Lybrand Smith, Commander, U. S. Navy

Flow Through Granular Materials, by B. A. Bakhmeteff and N. Feodoroff, Columbia University

Recent Developments of the Theory of Turbulence, by H. L. Dryden, National Bureau of Standards

A Theory for Sharp-Edged Orifices, by W. E. Howland, Purdue University (to be presented by title)

6:30 p.m. Picnic Supper

Taughannock Falls State Park

SATURDAY, JUNE 26

9:00 a.m. Elasticity Session

Chairman: H. M. Westergaard, Harvard University

The Load-Deflection Characteristics of Initially Curved Flexural Springs, by W. E. Johnson, General Electric Company

End Reactions and Stresses in Three-Dimensional Pipe Lines, by G. B. Karelitz and J. H. Marchant, Columbia University

Working Stresses for Members Subjected to Fluctuating Loads, by Joseph Marin, Rutgers University

Torsion of Rectangular Tubes, by W. Hovgaard, Brooklyn, N. Y.

The following papers will be presented by title:

Stress Systems in a Circular Disk Under Radial Forces, by R. D. Midlin, Columbia University

The Calculation of Maximum Deflection, Moment, and Shear for a Uniformly Loaded Rectangular Plate With Clamped Edges, by I. A. Wojtaszak, University of Michigan

On the Stability of a Clamped Elliptic Plate Under Uniform Compression, by S. Voinovsky-Krieger, Berlin

Deflection of Beams of Varying Cross Section, by M. Hetényi

Paper on Two-Dimensional Problems, by H. Poritsky, General Electric Company

9:00 a.m. Hydraulic Session

Chairman: L. F. Moody, Princeton University

Pitting Resistance of Metals Under Cavitation Conditions, by J. M. Mousson, Safe Harbor Water Power Corporation

Determination of the Relative Resistance to Cavitation Erosion by the Vibratory Method, S. L. Kerr, United Engineers and Constructors, Inc.

2:00 p.m. Plasticity Session

Chairman: S. C. Hollister, Cornell University

Recent Investigations in Plastic Torsion, by C. W. MacGregor and J. A. Hrones, Massachusetts Institute of Technology

Creep of Metals at High Temperatures in Bending, by E. A. Davis, Westinghouse Research Laboratories

Behavior of a Bed of Plastic Clay Resting on Rock Surface, by B. K. Hough (Soil Mechanics Laboratory of the U. S. Corps of Engineers) Cornell University

2:00 p.m. Hydraulic Session

Chairman: S. Logan Kerr, United Engineers and Constructors, Inc.

Round-table discussion on Cavitation

7:00 p.m. Dinner

Memorial room of Willard Straight Hall

Toastmaster: C. R. Soderberg, Westinghouse Electric & Manufacturing Co.

Address: Some Notes on the Work of the National Physical Laboratory, by H. J. Gough, National Physical Laboratory, England

Living Accommodations

Living accommodations will be mainly in Balch Hall, a dormitory located on the campus of the University. The charge will be $2 a day for one person for two days or $5 a person for three days. The rooms will be available after 1:00 p.m. on Thursday, June 24, and until 10:00 a.m. on Sunday, June 27. Reservations may

also be obtained at hotels in Ithaca or nearby private homes.

Reservations for dormitory accommodations should be made in advance with Prof. F. G. Switzer, College of Engineering, Cornell University, Ithaca, N. Y. Hotel reservations should be made directly with the Ithaca Hotel or the Clinton House.

Meals will be served in the cafeteria and dining room of Willard Straight Hall, headquarters building, at a reasonable price.

Women's Program

On Friday, June 25, from three to five o'clock there will be a tea at Willard Straight Hall for the women who are attending the meeting. The men will, of course, be welcome also. A picnic supper will follow in the evening at Taughannock Falls. For Saturday morning sightseeing trips around the campus have been planned while for the afternoon a bridge party is being arranged.

Golf at the Ithaca Country Club will be made available to guests with a greens fee of $1 for those attending the meeting.

Local Committee

Handling the local arrangements for the meeting are the following: H. Diederichs, honorary chairman, C. D. Albert, W. N. Barnard, C. Carmichael, R. F. Chamberlain, F. O. Ellenwood, S. G. George, S. C. Hollister, C. O. Mackey, E. W. Rettger, W. M. Sawdon, E. W. Schoder, and E. H. Wood.

200 Delegates at Graphic Arts Technical Conference in New York, May 6–8, 1937

Sessions on Management, Color-Printing Progress, and Paper and Printing

The eleventh annual Graphic Arts Technical Conference was held at the Hotel Commodore, New York City, May 6, 7, and 8, 1937. Three sessions, management, color-printing progress, and paper and printing, were held.

The Conference began on Thursday, May 6, which was devoted to registration and to inspection trips to the plant of R. Hoe & Company and the *New York Daily News*. At the Hoe plant there was a demonstration of high-speed newspaper unit printing and pasting, 55,000 copies per hour.

Management

Friday morning's session was opened, in the absence of Edward Epstean, President of the G.A.R.B., who is on a trip to Europe, by V. Winfield Challenger, vice-president. The chairman of the session on management was John Clyde Oswald, of the Gregg Publishing Company. Two addresses were made. The first "Training in the Printing Industry," by J. Henry Holloway, head of the New York Printing School, was most informative. Mr. Holloway pointed out that education in printing falls roughly into two classes, one dealing with the employed apprentice, and one with the students who come from public schools, to make their entry into the printing industry. The printing school renders a desired service to the industry by a process of selection—sometimes of rejection—the latter applying to applicants who prove early in their experience to be unsuited to a career in printing.

W. M. Passano, treasurer of the Waverly Press, Baltimore, Md., held the close attention of the members with a paper entitled "Employer-Employee Relations—Wages." The system at the Waverly Press includes a division of hours of work in the mechanical departments to four shifts of six per day. Employees are paid on a wage and not on a piece system. Standards of production have been set up that enable both employer and employee to profit by "bigger and better" results. The satisfactory outcome of operating the system has been a profit to both employer and employee. The workpeople are making as much in six hours as they formerly made in eight. Executives receive added compensation in the form of a share in the company's profits.

Color-Printing Progress

At the Color-Printing Progress session on Friday afternoon, the chairman was William C. Huebner, of Huebner Laboratories, Inc., of New York. Papers were presented, as follows: "Color Gelatine Printing," by Rudolph E. Fehse, Consolidated Film Laboratories; "Color Offset Printing," by Herman A. Bernhardt, Latham Lithographic Company; "Color Rotogravure Printing," by M. R. Pellissier, Gravure Foundation; and "Enclosed Ink Fountain for Gravure Printing," by Frederick W. Bender, manager, Alco-Gravure Division, Publication Corporation.

In Mr. Fehse's paper it was pointed out that great progress has been made in the photogelatine process. Improvement has been effected in developing gelatine plates so that it is now possible to print 8000 impressions per day on rotary presses, as contrasted with 2000 impressions per day on flat-bed presses.

Mr. Pellissier's paper on "Color Rotogravure Printing" began with the statement that "most of the trouble, or perhaps I should say the difficulties, in producing first class colorgravure appear to concentrate in two places—in the color separation in the first place and in the printing in the second. Efforts are being made to treat the matter of color in about the only way it seems likely to be solved, that is, by using stated pigments for the primary colors in the paints, water color or oil, that the artist may use to produce his originals, and identically the same pigments in the inks used by the

printer. Then too, the filters for the color separations are made to take care of these particular colors."

Mr. Bernhardt said: "I could very easily say that about everything in the color line is being done in the offset-color-printing field, and have very few people dispute the statement. However, as color-offset printing has demonstrated its dependability over such a large field, I will mention only the high spots. It lends itself to the reproduction of a very small subject. Miniature portraits consisting of fine detail and color graduations can be reproduced by color offset successfully by using a 300- or 250-line screen to retain all the delicate color values in their proper relation. Negatives properly made of such subjects and photocomposed on a press plate will result in the highest quality of color-reproduction work. From this, we go to a 24-sheet poster entirely made with color-offset printing methods. The various individual subjects that come within that wide range are too numerous to mention here.

Mr. Bender said regarding "The Effect of the Enclosed Ink Fountain on Intaglio Printing" that its story was that of one of the most vital innovations made in the process of intaglio printing in all of its 25 years of history. He predicted that the progress of color printing today, its quality, and its speed, due to the invention of the fountain, will make it the outstanding and most widely used printing process in the future.

Paper and Printing

At the Saturday morning session, devoted to paper and printing, Mr. R. G. Macdonald, secretary of the Technical Association of the Paper and Pulp Institute, presided. The first paper, entitled "Progress and Problems in Printing Rollers," was given by J. C. Dunn, of the Vulcan Proofing Company, New York. It was devoted principally to a discussion of the synthetic roller. Among other statements made by Mr. Dunn was that "properly designated and formulated synthetic compounds have many desirable qualities which make them suitable for inking-roller use. They are stable, not subject to rapid oxidation, are highly resistant to oils, solvents, and driers, unaffected by seasonal and temperature changes. They can be compounded to produce the proper degree of softness without swelling as rubber does. The manufacturing technique is similar to rubber, and synthetics have the additional advantage of having broader curing ranges."

J. B. Shaughnessy, of Woonsocket, R. I., talked on "Rubber Plates and Graphic Arts." He said that rubber printing plates are now being manufactured commercially for all classes of work. They have been found to be particularly suitable for use on cover stock, embossed papers of all types, handmade finishes, glassine, cellophane, celluloid, metallic papers, cloth, glass, tin, and other surfaces that ordinarily cannot be printed from metal plates or where perfect coverage without "mottle" and a minimum amount of ink is essential.

The concluding address was on "Rapid-Drying Inks on Web-Fed Papers," by Charles MacArthur, Harrison, N. J. Mr. MacArthur said "We may all agree that the major handicaps which hamper high-grade letterpress printing are: the presswork pests, setoff, smear, and smut; and make-ready, the so-called necessary nuisance." He added "that with respect to make-ready little can be said that hasn't been said before. It is the subject of discussion, controversy and dispute in every language on earth where high-grade printing is produced. Printing without make-ready is the fond hope of every press owner, printing salesman, and cost estimator, and anyone who promises to print without make-ready is sure of a hearing, especially, if the listener has never operated a press."

A luncheon meeting was held between the sessions on Friday. Hon. A. E. Giegengack, Public Printer, Washington, D. C., presided, and addresses were made by James H. Herron, President of The American Society of Mechanical Engineers, and Dr. Harvey N. Davis, President of Stevens Institute of Technology.

The newly elected president called a meeting of the Council at a luncheon held at the close of the session on Saturday. Two committees were appointed, one consisting of Fred Hoch, Charles Clarkson, T. E. Dalton, Wells Harvey, and Summerfield Eney to serve on Standard Practices in the Graphic Arts. The other was a committee on Education composed of W. R. Maull, Harry L. Gage, and John Clyde Oswald

About two hundred delegates were registered.

JOHN CLYDE OSWALD

Summer Meeting of A.S.M.E. Oil and Gas Power Division, State College, Pa., August 18 to 21

MEMBERS OF THE A.S.M.E. Oil and Gas Power Division are looking forward to the annual summer meeting this year to be held at Penn State College. The sessions begin on Wednesday, August 18, with registration in the morning and end on Saturday noon, August 21.

Those who have attended meetings at Penn State College in the past do not need to be told about the advantages of this choice of meeting place. For the benefit of those who have never been there, it is no exaggeration to say that the Nittany Lion Inn, where exhibits are located and all sessions are held, is one of the most modern and comfortable hotels in that part of Pennsylvania. The golf course, which is available to those in attendance at the meeting for a very modest fee, has received many enthusiastic compliments.

The technical program for the meeting has not yet been entirely completed but in a preliminary way it may be said that there will be interesting papers on new developments in the Diesel and gas-engine fields, reports of research on fuels and injection apparatus, latest information on automotive and railroad Diesel-engine applications, the Annual Report on Oil Engine Power Cost, a review of metallurgical advances, and discussions of operating problems.

Meetings at Penn State have usually been scheduled for the latter part of June, just after the end of the school year. This year, however, those making the arrangements felt that an August date might influence many to combine attendance at this meeting with their annual vacations. At least it may be said that very few conventional vacation resorts offer the facilities and climate that are to be found at State College. A rather large attendance is expected and, because the Inn has hardly enough rooms to take care of all that may decide to come, arrangements have been made to accommodate the overflow in the College dormitories. Those who would like to stay at the Inn should send in their reservations promptly in order to be sure of being taken care of.—M. J. REED

A.S.M.E. Members Honored by The Franklin Institute

AT THE Medal Meeting of The Franklin Institute, Philadelphia, Pa., on May 19, 1937, three members of The American Society of Mechanical Engineers were among those honored.

Longstreth Medals were presented to John S. Haug, consulting engineer, United Engineers and Constructors, Inc., Philadelphia, and to Herbert L. Whittemore, chief, Engineering Mechanics Section, Bureau of Standards, Washington, D. C.

To Rupen Eksergian, of the Edw. G. Budd Mfg. Co., Philadelphia, Pa., was presented the Henderson Medal.

Ithaca Section Holds Its First Meeting

THE first meeting of the Ithaca Section of the A.S.M.E. was held in Willard Straight Hall, on the campus of Cornell University, on April 23. Prof. F. G. Switzer, organizing officer, presided. There were 26 in attendance, including three guest speakers, four members of the Rochester Section of the A.S.M.E. and the Rochester Engineering Society, and 19 members of the Ithaca Section.

Dinner was served at 6:30 and immediately afterward the meeting was called to order by the chairman. The first speaker was James W. Parker, manager of the Society, who spoke on the relationship between local sections and the national organization. Ernest Hartford, assistant secretary of the Society, gave the members some practical advice and information on the organization of a Section.

In the business session which followed officers were elected to the executive and nominating committees of the Section: The executive committee elected included H. E. Holford, L. W. Morrow, E. F. Murphy, W. M. Sawdon, F. G. Switzer, and M. P. Whitney. Members of the Nominating Committee are A. O. Carpenter, H. O. Palmer, and C. W. Vail. Mr. Sawdon was elected chairman, Mr. Whitney vice-chairman. Colin Carmichael was appointed secretary-treasurer.

Greetings were extended to the new Section

from Prof. W. N. Barnard, acting director of the Sibley School of Engineering, Cornell University, and I. G. McChesney, secretary-treasurer of the Rochester Section of the Society.

Dean R. L. Sackett, vice-president of the A.S.M.E., brought congratulations to the Section from the parent Society, and told something of the semiphilanthropic activities to which the Society lends support. He pointed out the responsibility of the Local Sections in keeping members remote from headquarters well-informed in all phases of Society work.

President Herron Addresses A.S.M.E. Metropolitan Section

"WHAT the Members Can Do for Their Society" was the subject of an address by President James H. Herron of The American Society of Mechanical Engineers at a meeting on April 22, 1937, of the Metropolitan Section of the Society. Past-President Roy V. Wright presided.

Following President Herron's address Herbert Thompson Strong gave an illustrated demonstration lecture entitled "Exploring the Magic World of Color." Using ultraviolet rays and polarized light Mr. Strong displayed some of the extraordinary combinations of color to be found in ordinary looking materials, and quite successfully astounded his audience by demonstrating to an amazingly magnified scale and in full color the growth of crystals from drops of substances on glass.

At the close of the meeting members and guests were given an opportunity to meet President Herron and talk with him informally.

President Herron said that the difficulties of the office of president of the Society had been materially eased by the effective work being done by the senior councilors, who had been organized in President Batt's administration to maintain close contact with members in the various geographical areas of the country which they severally represented. It was the Society's wish, he said, that the president be a man in full professional career, and such a president could not spend his entire time on visits to sections and student branches. Aside from such visits on behalf of the Society as the president and senior councilors might make, those by the secretary provided valuable means of intimate contacts with members.

He recalled that this year marked the fortieth anniversary of his membership in the Society and confessed that he valued that membership as highly as anything in his professional experience. He then asked his hearers what would happen if they were without professional contacts and if they realized how dependent they were on fellow engineers. Furthermore, could they say that they were free from the influence of civil, electrical, mining, metallurgical, and chemical engineers? His experience had covered all phases of engineering and he had come into personal contact with the engineers representing all these fields. No one man, he contended, was responsible for the development of the art of engineering. For its continued growth and in order that engineers might take their place in the sun, they must face the need for cooperation.

Using many examples of the cooperation of engineers in practice in solving technical problems, he showed how much could be learned by one engineer from another. In engineering societies, whose success depended on their members, a member got out what he put in, and many times with interest.

He made an earnest plea for the engineer to publicize his work and expressed the opinion that there was no objection to "dressing up" engineering achievements to make them news. Citing the success of the American Chemical Society in stimulating the public's interest in chemistry, he said that he was anxious to see the engineer effective not only in his profession but in the public mind as well. But in order that engineers might get into the public scene, he concluded, it would be necessary for them to demonstrate unity of purpose.

A.S.M.E. Calendar

of Coming Meetings

June 25–26, 1937
Applied Mechanics and Hydraulic Meeting
Cornell University

August 18–21, 1937
Oil and Gas Power Meeting
Pennsylvania State College
State College, Pa.

September 22–24, 1937
Erie Meeting
Erie, Pa.

October, 1937
Wood Industries Meeting
Grand Rapids, Mich.

October 15, 1937
Textile Meeting
Boston, Mass.

December 6–10, 1937
Annual Meeting
New York, N. Y.

PORTION OF PRECISION-GAGE LABORATORY OF THE ORDNANCE DEPARTMENT, U. S. ARMY, RECENTLY ESTABLISHED AT NEW YORK UNIVERSITY

(Major de Zafra is shown demonstrating one of the instruments to members of his class.)

U. S. Army Precision-Gage Laboratory Set Up at N. Y. U.

NEW YORK UNIVERSITY has recently announced that the Ordnance Department of the United States Army has established a complete precision-gage laboratory at the College of Engineering, New York University, University Heights, New York, N. Y. The laboratory is for the use of the Army, the College of Engineering, and industry generally.

Carlos de Zafra, member, A.S.M.E., major in the Army Reserve Corps and chief of the Gage Division of the New York Ordnance Division, is in charge of the laboratory. Major de Zafra is making use of the laboratory and the instruments, all of which have been calibrated by the National Bureau of Standards instruments at Washington, in his classes at the college.

University Night at A.S.M.E. Washington, D. C., Section

ONE hundred and fifty members and guests of the Washington, D. C., section of The American Society of Mechanical Engineers held a "University Night" meeting on the evening of April 8, 1937, at which Dr. Lyman J. Briggs, of the National Bureau of Standards, delivered the principal address. The meeting was preceded by a dinner at which 77 persons were present, most of whom were students from the Catholic University, George Washington University, The Johns Hopkins University, and the University of Maryland.

The meeting was held at the Engineering Auditorium of the University of Maryland, College Park, Md. Dr. Briggs's address was entitled "Stratospheric Flights and Their

Engineering Lessons." In his report of the meeting, M. X. Wilberding, chairman of the Washington, D. C., Section, makes grateful acknowledgment of the assistance of the Baltimore Section and of the Student Branches of the participating universities.

The Washington Section announces that it is offering a prize to one of the members of the student branches at the Catholic University and to one at the George Washington University. The prize will take the form of the first year's dues of the winners as junior members of the A.S.M.E.

Cleveland Junior Group Has Successful Season

INCREASING interest in Society affairs particularly among members of the Junior Groups in several local sections of The American Society of Mechanical Engineers bears testimony to the general improvement in industrial conditions throughout the nation and to the vigor of younger men taking part in professional development. Correspondence from the Cleveland Junior Division of the Society indicates that a successful season of meetings and plant visits has been under way and that attendance has far exceeded expectations.

The junior committee of the Cleveland Section is under the chairmanship of G. E. Carson, of the Case School of Applied Science. Augmented by their women guests, members of the Division recently participated in an inspection of radio station WHK and the air-conditioning plant of the Higbee Department Stores. An attendance of 80 persons was recorded. On a later occasion William E. Brill, of the Winton Engine Company, addressed the division on "Modern Diesel Engines." Following the address the members present were conducted through the Winton Engine Company's plant where the meeting was held.

A.S.M.E. Management Division Appointments

AT A meeting on March 30, 1937, of the executive committee of the Management Division, The American Society of Mechanical Engineers, it was announced that invitations to serve as representatives of the division in their respective local sections had been accepted by several members of the Society. Those whose acceptances have been received are as follows: F. A. Barnes, Cleveland; F. C. Spencer, Plainfield; B. A. Gayman, San Francisco; P. O. Yeaton, Florida; N. H. Barnard, Nebraska; T. H. Kerr, Columbus; W. M. Passano, Baltimore; M. X. Wilberding, Washington, D. C.; G. H. Shepard, Indianapolis; A. Langsner, Chicago; J. R. Tanner, Pittsburgh; A. R. Stevenson, Schenectady; and W. W. Nichols, Detroit.

Leonard Baker, of the Dexter Folder Company, was appointed chairman of the Subcommittee on Job Shop Management, to replace A. J. Graf, resigned.

With the Technical Committees

Soldered Joints in Copper-Tube Piping

RESEARCH and standardization of copper and brass fittings with soldered joints form part of the program of the Sectional Committee on Minimum Requirements for Plumbing and Standardization of Plumbing Equipment (A40) of which W. C. Groeniger is chairman.

A. M. Houser is chairman of the standardization subcommittee and R. S. Weston is chairman of the research subgroup which is continuing the research on this project at the National Bureau of Standards which was begun under the auspices of the F.H.A. The Copper and Brass Research Association is co-operating with the research subgroup on this project, which is one of several included within the scope of the sectional committee. Important suggestions for the expansion of the research program of the committee were made at a meeting held in New York this spring.

This investigation at the Bureau has been conducted by A. R. Maupin as research associate since February, 1936, under the general direction of H. S. Rawdon, chief of the Division of Metallurgy.

This study includes at present (1) the most satisfactory maximum and minimum tolerances of the bore of the fittings, (2) the minimum depth of bore, (3) strength of tin-lead solder joints, (4) strength of tin-antimony solder joints, and (5) creep of joints at 250 F under load of 220 lb over a period of 1000 hr.

A few copies of the progress report covering the first year of this research are available to those especially interested on application at A.S.M.E. headquarters.

Subgroup on Graphical Symbols Meets

FOLLOWING the publication of the American Standard for Graphical Symbols (Z14.2-1935) in 1935 all of the standardization work on graphical symbols under the American Standards Association procedure was concentrated in a new sectional committee of which H. W. Samson is chairman. This committee has split the job into two parts, one dealing with symbols for use in mechanical engineering, Prof. T. E. French, chairman, and the other, symbols for use in electrical engineering, H. W. Samson, chairman.

During the April, 1937, group of A.S.M.E. technical committee meetings the subgroup appointed to expand Z14.2-1935 to include graphical symbols for heating, ventilation, refrigeration, and air conditioning held its first meeting. Chairman E. E. Ashley presided for a time and then turned the chair over to John James. Seven of the eight members were present. At this meeting detailed plans were made for the collection of the necessary information on present practice and for working it up into a suitable form for consideration for approval as an American Standard. One of the major parts of these data is the group of line symbols for piping installations to indicate the nature of the fluid which is to be carried.

Harvey N. Davis Addresses Metropolitan Juniors

THE Junior Group of the A.S.M.E. Metropolitan Section wound up its scheduled program for the season by inviting members of the local student branches to a smoker on May 7. The speaker of the evening was Dr. Harvey N. Davis, president of Stevens Institute of Technology, who spoke on "Psychology at Work in Industry." As president of an engineering college Dr. Davis was one well suited to address a joint meeting of student engineers and those newly started in the profession.

President Herron and Roy V. Wright attended with Dr. Davis and greeted the members. An enthusiastic group joined in discussing the topic informally after the meeting.

Safety Code for Conveyors and Conveying Machinery

THE formulation of a Safety Code for Conveyors and Conveying Machinery was taken up with renewed interest at the reorganization meeting of Sectional Committee (B20) on Wednesday, April 21, 1937, at the A.S.M.E. headquarters. Fourteen persons were in attendance. H. H. Judson, chairman of the A.S.M.E. Standing Committee on Safety, presided and Cyril Ainsworth, assistant secretary of the American Standards Association, outlined the purposes and policies of his association. The National Bureau of Casualty and Surety Underwriters and The American Society of Mechanical Engineers are the joint sponsor bodies and the personnel includes official representation of 22 national organizations.

At this reorganization meeting the committee elected as temporary chairman, D. L. Royer of the Ocean Accident and Guarantee Corporation, Ltd., New York, N. Y. Mr. Royer represents the National Bureau of Casualty and Surety Underwriters on the sectional committee. It also elected Prof. George W. Barnwell of Stevens Institute of Technology, Hoboken, N. J., representing the Society for Advancement of Management as temporary secretary.

The scope of the committee's work, as originally approved by the A.S.A., was reviewed and revised to include the following five groups of conveyor types: (1) All types of chain conveyors, belt conveyors, belt elevators including steel belt, and screw, track, or scraper conveyors; (2) gravity conveyors and chutes, live roll conveyors; (3) cable-operated and cable flight conveyors and cableways; (4) air, steam, or liquid conveyors; and (5) tiering, piling, and stacking conveyors. Five subcommittees are being formed to prepare the original drafts of the sections of the code dealing with the several groups.

The Members' Page

A Forum for Frank Discussion by A.S.M.E. Members

Mechanical-Engineering Education

The Member's Page:

The American Society of Mechanical Engineers rightfully should be a leading factor in mechanical-engineering education. A great opportunity exists in this respect, and I believe that an organized program can be planned and pursued which will be of great benefit to all members of the Society as well as to students in mechanical engineering. This work can be made self-supporting; it will increase the value of membership in the Society; it will increase the prestige of the Society; it should result in an increase in the membership; and it will be an outstanding contribution to the profession. At least three phases of educational activity can be organized:

(1) Courses of instruction on specialized subjects in mechanical engineering can be instituted

(2) Short series of lectures should be given

(3) Printed reports of technical meetings held by Local Sections of the Society should be available.

These courses will deal with more technical aspects of the subjects than is usual or advisable in engineering colleges, whose duty is to teach engineering fundamentals. Among such courses might be air conditioning, refrigeration, fluid mechanics, process machinery, elimination of vibration in machinery, development of machines and mechanical applicances, power-plant layout, selection of materials for mechanical-engineering projects, and many other subjects. Two or three courses might be presented each year at the Society's headquarters in New York. Then, if the demand warrants, each course may be repeated in various sections of the country by different sets of lecturers. The lectures would be given by practicing engineers in the specialized fields. Thus courses of a strictly professional nature, and based upon the very latest practice, would be given. In instances where a review of fundamentals is desirable preliminary to a course, engineering teachers would be called upon for cooperation. In some cases, a single lecturer will present an entire course, but, in most cases, a number of specialists will be invited to participate, each dealing with specific phases of the subject which will be carefully coordinated. The lectures and discussions can then be published in book form for the benefit of those members who are unable to attend the courses. Only members of the Society and students who are enrolled in accredited engineering schools should be allowed to attend the lectures. A registration fee should be charged. The resulting publications may be sold, the charge to nonmembers being higher than to members. If these courses are submitted to engineering colleges for approval, and perhaps cooperation in presentation, I feel sure that credit for these courses, as electives, toward degrees will be allowed. For such credit, study of additional references, some problems and reports, and probably, a final examination would be necessary. This aspect of the problem can be handled in various ways.

Short series of lectures probably offer the greatest opportunities in an educational program. From two to about six sessions can be devoted to specialized technical subjects, either a single lecturer or several lecturers handling the series. A registration fee should not be charged, but only members of the Society and students in engineering schools should be allowed to attend. Some typical subjects for these short series might be selection of machine tools, modern trends in machine-tool developments, instruments of control in power plants, modern practice in lubrication, noise elimination in machines, use of alloys in machines, modern steam-turbine practice, patent law, market investigations relating to mechanical products, effective cutting of metals, presswork in quantity production, essentials of jig and fixture design, financial analysis of engineering projects, streamlining, Reynolds' number and its use, laws of similitude in testing of reduced-scale models, and statistics as applied to engineering. Another professional society is following this plan, and it is proving very successful. I recently attended one of the sessions of a series being presented in a Middle-West city. It was excellent and was attended by about 160 men.

Many papers on important topics of professional interest are presented and discussed by outstanding specialists at the various Local Section meetings. To finance the publication of these papers and discussions is, of course, impossible. Most members cannot, for one reason, or other, attend these meetings, and, therefore, only comparatively few members benefit. Also, the author of an outstanding contribution does not receive the professional recognition that he deserves. Every year, several papers on topics that are of professional interest to me are presented in my own Local Section. Unfortunately, I have not been able to attend these meetings. I also see frequent notices of papers on topics that are important to me which are presented at meetings of other Local Sections, but unfortunately, they are not published. Other members have mentioned similar experiences. My suggestion is that papers of this kind, which appear to warrant it, be made available, together with the discussion, to those willing to pay a nominal charge.

To institute a successful educational program such as I present will naturally require considerable planning and coordination. The individual undertaking the direction of this important work should have broad experience in engineering education and professional engineering. He should have a wide acquaintance in both fields and possess organizing and executive ability. This man should have a committee of practicing engineers and engineering educators to work with him. I am sure that eminently qualified members of the Society are sufficiently interested in it and in their profession to accept appointment to a committee such as this.

I suggest that Council consider an educational program along the lines that I have outlined, a Committee on Education be appointed, and the plan be given a trial at once. As chairman of the mechanical-engineering division of the Society for the Promotion of Engineering Education I assure you of the cooperation of that group.

Frank L. Eidmann.[1]

[1] Professor of mechanical engineering, Columbia University, New York, N. Y. Mem. A.S.M.E.

Other Engineering Activities

Labor, Wages, Prices—Theme of Engineers' Economics Conference, June 18 to 26

Society for the Promotion of Engineering Education Joins Stevens Institute of Technology in Sponsoring the 1937 Conference

"LABOR, Wages, and Prices and Their Interrelations" will be the general theme for the seventh annual Economics Conference for Engineers to be held at the Stevens Engineering Camp at Johnsonburg, N. J., from June 18 to 26. The conference will be under the joint auspices of the Society for the Promotion of Engineering Education and Stevens Institute of Technology.

Preliminary plans for the conference have been made by the Committee on Engineering Economy of the Society for the Promotion of Engineering Education of which Prof. E. L. Grant of Stanford University is chairman.

EVENING SESSIONS ON LABOR PROBLEMS AND INDUSTRIAL RELATIONS

The first session of the conference will be held on Friday evening, June 18, when John M. Carmody, administrator of the Rural Electrification Administration and formerly a member of the National Labor Relations Board, will speak on "What Engineers Should Know About Labor Problems." Speakers at sessions of the seven succeeding evenings are: S. L. Andrew, chief statistician of the American Telephone & Telegraph Co., on "The National Income, Wages, and Prices;" Ralph E. Flanders, president of Jones & Lamson Machine Co., past-president A.S.M.E., on "Fundamental Changes in Our Economy;" Prof. F. V. Larkin, Mem. A.S.M.E., director of the department of mechanical engineering of Lehigh University, on "Training and Wages in Industry;" J. Frederick Dewhurst, economist of the Twentieth Century Fund, on "Financing Social Security;" W. H. Rastall, formerly chief of industrial machinery division of the U. S. Department of Commerce, on "The Effect of Government Policies on Engineering Industries;" Prof. Noel T. Dowling, of Columbia University Law School, on "The Constitution and the Courts;" and A. R. Mathieson, assistant to the vice-president of the United States Steel Corporation, on "Industrial Relations."

MORNING CONFERENCES ON INDUSTRIAL ECONOMICS, PSYCHOLOGY, AND MANAGEMENT

The forenoon sessions of the Economics Conference will be arranged in closely related groups of eight lectures each, a conference member electing two of these condensed courses in addition to the evening sessions. Dr. D. S. Kimball, formerly dean of engineering of Cornell University and past-president, A.S.M.E., and Dr. W. D. Ennis of the Stevens faculty and treasurer A.S.M.E., will conduct a course in industrial economics. Dr. R. S. Uhrbrock, head of research department, industrial-relations division of the Procter & Gamble Co., will be in charge of eight sessions on industrial psychology. Prof. George W. Barnwell of Stevens Institute of Technology will be in charge of seminars dealing with industrial management. Among others who will lead discussions in morning conferences are Prof. Karl Scholz, of the Wharton School of the University of Pennsylvania, Prof. Scott B. Lilly of Swarthmore College, Prof. F. L. Eidmann of Columbia University, Mem. A.S.M.E., Prof. Eugene L. Grant of Stanford University, Prof. P. T. Norton, Jr., of Virginia Polytechnic Institute, Mem. A.S.M.E., Prof. C. L. Eddy of the Case School of Applied Science, K. W. Jappe, Mem. A.S.M.E., engineer and economist, formerly president of the Brookmire Economic Service, Prof. Edmund D. Ayres of the University of Wisconsin and President A. R. Cullimore, Mem. A.S.M.E., of the Newark College of Engineering.

A.S.T.M. to Meet in New York June 28–July 2

AFTER a lapse of 25 years, New York has again been chosen by the American Society for Testing Materials as the place for its annual meeting. The earlier meeting was held in March, 1912, and the Society also participated in the Sixth International Congress for Testing Materials which was held at New York in September of that year. Sessions of the forthcoming Fortieth Annual Meeting will be held at the Waldorf-Astoria from June 28 to July 2, inclusive.

Over 20 formal sessions are scheduled, several of these being symposia at which groups of papers will be presented. Topics to be discussed include significance of coal and coke tests, correlation of laboratory and service tests of paints, and a critical discussion of present-day practice in consistency measurements. Numerous papers will also be presented on various subjects and problems in the asphalt field, water for industrial uses, correlation of cast-iron's physical properties with casting thickness, nonferrous metals, masonry materials, general testing, and other topics of interest.

The fourth biennial exhibit of testing apparatus and related equipment, which is sponsored by the A.S.T.M., will be held during the week of the meeting.

An extensive exhibit is being planned by the Joint A.S.M.E.-A.S.T.M. Committee on Effect of Temperature on the Properties of Metals. Other committee displays will feature the extensive corrosion-test programs now under way; photomicrographs, radiographs, and X-ray photographs as used in metallography; and electrical insulating materials.

Chemical Industries Exposition Announced for Dec. 6–11

DYNAMIC displays designed to show the coordination of each phase of chemical manufacture with the many industries to which it is related will be a feature of the Sixteenth Exposition of Chemical Industries that will be held at the Grand Central Palace, New York, N. Y., Dec. 6–11. These displays will emphasize the role of the industry in the reconstruction period now under way. Another feature of the exposition will be a prize competition for a slogan that typifies the part played by chemistry in modern life by representing accurately the objectives of the chemical industries and the benefits accruing to mankind from their activities.

A.S.A. Issues Report on Exhaust Systems

THE American Standards Association has just released a report on fundamentals relating to the design and operation of exhaust systems which has a direct bearing upon the problem of occupational-disease prevention. This report was presented at the recent National Conference on Silicosis in Washington by the Engineering Committee of the Conference.

Different types of dusts and gases require different treatment. Yet there are certain fundamental engineering principles common to the control of all. It is these basic engineering principles that the committee deals with in its present report.

Today many state regulations demand that employers provide "adequate" ventilation. But what is "adequate?" Some laws and codes require a definite amount of static suction as an index of exhaust-system efficiency, but there are other engineering principles involved. What are the minimum air velocities required to "capture" the dust arising from certain grinding-wheel processes or the fumes from electroplating? To what extent is air-cleaning practical to prevent recontamination of plant air from the outside, or to permit recirculation of air discharged from the exhaust system in the plant? What pressure losses may an engineer expect from the various types of elbows and branches common to exhaust piping? The report goes into the question of plant layout, exhaust-hood design, air velocities, methods of measuring static suction, as well as the matter of exhaust system piping and of maintenance.

The report is intended as a guide to those desiring to install and use exhaust systems as

well as to the manufacturer and designer of such systems. The committee that developed this report does not consider it in any way final but hopes that through its critical analysis a body of technical experience may be built up on which to base future action in the elimination of industry's worst occupational-disease hazard—toxic dusts and gases.

This is the first step in developing a set of separate standard specifications for exhaust-hood designs and air velocities for each distinct process or industry in which the occupational-disease hazard is present. In all this work a national committee of eminent toxicologists and pathologists headed by Dr. R. R. Sayers, senior surgeon of the U. S. Public Health Service, is acting in an advisory capacity to set threshold limits beyond which the presence of certain dusts and gases becomes a menace to workers.

The A.S.A. Committee on Exhaust Systems which released this report includes representatives of 22 organizations, of which The American Society of Mechanical Engineers is one, working under the administrative leadership of the International Association of Industrial Accident Boards and Commissions.

Theodore F. Hatch, who is a member of the A.S.M.E. and associated with the Division of Industrial Hygiene, New York State Department of Labor, is chairman of the subcommittee which drafted the report.

Summer Conference on Teaching of Mechanical Engineering

M.I.T. and Harvard Hosts at Cambridge, June 28–29

AT THE Summer Conference on the Teaching of Mechanical Engineering to be held in Cambridge, Mass., June 28 and 29, under the auspices of the mechanical engineering division of the Society for the Promotion of Engineering Education, the following papers will be presented:

How Is Present-Day Training of Mechanical Engineers to Recognize the Transition From the Practical Engineer of 25 Years Ago to the Applied Scientist of Today? by Jerome C. Hunsaker, head of the department of mechanical engineering, Massachusetts Institute of Technology.

What Are the Aims and Objectives of Mechanical Engineering Education? by Geo. A Orrok, consulting engineer, New York.

What Subjects of Instruction Should Be Included in All Courses in Mechanical Engineering? by F. D. Carvin, head of mechanical engineering, Newark College of Engineering.

Some Comments From Industry Regarding Present-Day Training of Mechanical Engineering Students, by Frank L. Eidmann, professor of mechanical engineering, Columbia University.

Who Is a Good Teacher? by Karl T. Compton, president of Massachusetts Institute of Technology.

Factors Contributing to Effective Teaching of Mechanical Engineering, by A. A. Potter, president of the American Engineering Council; dean of engineering, Purdue University.

Six simultaneous discussion groups will be held on the evening of June 28. The discussions will be on the advances and trends in the teaching of (1) heat engineering; (2) experimental mechanical laboratory; (3) machine design and related subjects; (4) heat-treating and metallurgy; (5) hydraulics and fluid mechanics; and (6) the selection of materials for engineering projects.

The hosts upon this occasion will be Massachusetts Institute of Technology and Harvard University. Prof. Frank L. Eidmann, professor of mechanical engineering at Columbia University, is chairman of the Conference.

The previous special summer conference of the teachers of mechanical engineering was held at Purdue University, Lafayette, Indiana, in 1929, and those who attended the Purdue conference will hold a reunion luncheon at the conference in Cambridge.

W. S. Hays Made Managing Director of A.W.S.

APPOINTMENT of Warner S. Hays as managing director of the American Welding Society was announced by A. E. Gibson, president of the Society. This appointment is part of the program, which was adopted by the board of directors at the last annual meeting, and is expected to lighten the load carried by the officers and members, thus enabling the Society to serve its members and the welding industry to better advantage.

Mr. Hays is a past-president of the American Trade Association Executives, a member of the Philadelphia Rotary Club, the Yale Club of New York and is on the Executive Committee of the Yale Engineering Association. Since the war, he has maintained his own consulting, engineering, and association executive office in Philadelphia.

Appointments Available as Battelle Research Associates

FOUR appointments as Research Associate will be available at Battelle Memorial Institute, Columbus, Ohio, for the year 1937–1938. Appointments are for September to August, inclusive. These appointments are open to graduates of any accredited university or college. Preference will be given to men who have completed one or more years of graduate study in chemistry, physics, metallurgy, fuel technology or ceramics; or who have demonstrated marked aptitude for scientific research in their industrial experience.

The Research Associates will be members of a new division of the Institute which will supplement the regular technical staff. The purpose of the Research Associate Division is to extend the work of the Institute in fundamental science and at the same time to develop highly trained research men for industry.

Appointments as Research Associate will be for one year's duration, including vacation, and may be extended for a second year. The salary will be from $1200 to $1800 a year, depending upon the training and experience of the individual. Research Associates will be expected to devote their entire time to a research project approved by the Director and supervised by members of the Institute staff. Research projects will be of a fundamental or general character looking toward the publication of information that will be useful to science and industry.

Battelle Memorial Institute was established under the will of Gordon Battelle to contribute to industrial progress through scientific research. The activities of the Institute are carried on under nine main divisions: Applied chemistry, industrial physics, process metallurgy, physical metallurgy, ceramics, refractories, fuel technology, ore dressing, and coal washing. Each division is equipped and staffed to carry on research under the direction of a specialist who is qualified by training and experience to direct original research in his field.

Application forms and further information, may be secured by writing the Director, Battelle Memorial Institute, Columbus, Ohio.

Heating Engineers to Discuss Air Conditioning

THE semi-annual meeting of the American Society of Heating and Ventilating Engineers will be held at the New Ocean House, Swampscott, Mass., June 24–26. Technical papers will be presented at sessions in the morning of each day, with a golf tournament in the afternoon of the first two days, and a banquet and dance in the evening of the second day. Air conditioning and cooling will be the principal topic of discussion at the meeting; 6 of the 11 papers announced dealing with some phase of the subject.

Plans Announced for E.I.C. Semicentennial

ANNOUNCEMENT has been made of the program of the semicentennial of The Engineering Institute of Canada, to be held at the Windsor Hotel, Montreal, P. Q., June 15 to 18, 1937.

On the morning of June 15 at the official opening session official representatives of engineering societies throughout the world will present their greetings. This will be followed by the presentation of honorary memberships and of prizes. The afternoon will be given over to the reading of technical papers and the evening to a reception and supper dance. Additional technical papers are sched-

uled for June 16; and a banquet will be held that evening at which Lord Tweedsmuir, Governor General of Canada, will be the guest of honor and principal speaker. Thursday is reserved for inspection tours and a garden party on the McGill University campus in the afternoon.

On Friday, June 18, the meeting will reassemble at the Chateau Laurier, Ottawa, for a luncheon, inspection trips, and a dinner and dance.

The American Society of Mechanical Engineers will be represented at the Semicentennial by James H. Herron, president of the Society.

Congress of Documentation, Paris, August 16–21

UNDER the auspices of the International Committee of Documentation, a world congress of documentation will be held at Paris, August 16–21. At this congress, which will meet during the time of the Paris Exposition, plans will be discussed for the formation of a parliament of documentation by all groups and organizations interested in the use and preservation of reference material on all subjects. This parliament would serve as a medium for research into principles, programs, and methods of documentation; interchange of information on results obtained; and formulation of plans for work that can be done to render documents available to workers in various countries and the service that can reasonably be expected from organizations having collections of documents.

Incorporation of American Documentation Institute

DEVELOPING and applying photomicrography to library, scholarly, scientific, and other material is a major objective of the recently incorporated American Documentation Institute. The formation of the Institute as a Delaware corporation that is organized on a nonprofit basis for educational, literary, and scientific purposes resulting from a meeting at Washington, D. C., on March 13, which was attended by delegates from national councils, societies, and other organizations. Members of the board of trustees are Dr. R. C. Brinkley, Western Reserve University; Dr. S. J. Buck, director of publications, National Archives; Watson Davis, director, Science Service; Dr. J. T. Gerould, librarian, Princeton University; and Dr. Ludvig Hektoen, chairman, National Research Council.

The documentation activities conducted by Science Service for the last two years in coöperation with the Naval Medical School, Library of the Department of Agriculture, Bureau of the Census, Library of Congress, and other agencies as a service to research workers and the auxiliary publication through microfilm which has been conducted by coöperation with leading scholarly and scientific journals will be transferred to the American Documentation Institute.

An Institute of Ceramic Engineers Proposed

AT A meeting, April 12, 1937, at Rutgers University, New Brunswick, N. J., of the executive committee of the Board of Trustees of the American Ceramic Society it was voted to approve the appointment of an organizing committee for a proposed Institute of Ceramic Engineers, with authority to circularize the membership of the American Ceramic Society and determine who are interested in becoming members of the proposed Institute. The organizing committee appointed comprises A. F. Greaves-Walker, chairman; R. E. Birch, vice-chairman; C. M. Dodd, secretary; and E. H. Fritz and H. E. White, members of the committee.

The executive committee also announced its representatives in other organizations. H. R. Straight, of Adel, Iowa, and W. Keith McAfee, New Castle, Pa., are the representatives for the Petroleum and Process Industries Divisions, respectively, of The American Society of Mechanical Engineers.

The News From Washington

By American Engineering Council

A.E.C. Asked to Advise Legislation on Engineering Experiment Stations

THE American Engineering Council is being called upon by members of Congress, engineers, and educators in the land-grant-college groups to support legislation proposing to increase the number of engineering experiment stations and for advice regarding the attitude which should be taken toward such legislation. It appears that there is competition between the agricultural and mechanic arts colleges and state universities for the allocation of funds for the construction and operation of engineering experiment stations.

The Florida Engineering Society passed a resolution at its annual meeting in March and is pressing American Engineering Council to support S.1679 and H.R.3629, introduced by members of Congress from Florida. Several engineers who are influential in Florida have also written urging action. The American Society of Heating and Ventilating Engineers which is not a member of American Engineering Council, has asked The American Society of Mechanical Engineers and American Engineering Council to support House Resolution 3629, providing for the establishment of engineering experiment stations at land-grant colleges.

The A.E.C. staff has advised The American Society of Mechanical Engineers to suggest that the American Society of Heating and Ventilating Engineers take competing legislation into consideration. H.R.5531, "to aid engineering and industrial research in connection with colleges and schools of engineering in the several state and territorial universities and colleges and for other purposes" seems to be in competition with S.1679 and H.R.3629, "to provide for establishing engineering experiment stations in the land-grant colleges."

Another remotely related group of legislation is found in S.1308 and H.R.4954, "to aid business and economic research in connection with collegiate schools of business in the several state and territorial universities." Those bills do not specifically include engineering but they do propose "to promote scientific investigation."

So much confusion has arisen regarding this legislation that President Roosevelt has appointed three committees to study it. The National Research Council was first called upon to appoint a Committee headed by Charles W. White. After that Committee had got into action, some question arose as to whether it should make a final report and the President appointed a Committee on Industrial Training headed by Floyd Reeves, of Chicago, who was formerly director of personnel with the Tennessee Valley Authority. A third committee has just been started by the National Resources Committee to investigate human resources which subject is understood to include questions regarding engineering educational facilities in land-grant colleges.

In addition to the legislation referred to, money is now being appropriated from relief funds to colleges for research and other purposes through three different organizations: under relief projects set up under the Works Progress Administration, under the National Youth Administration, which operates under a committee of which Joseph Roach is chairman and Audrey William is director, with substations in each state dealing with appropriating funds to the colleges and universities in each state, and a program of expenditure under Frank Persons of the Department of Labor for special purposes.

Such appropriations add to the confusion of purpose in current legislation and indicate that engineers should make a careful study of the entire situation before approving any of the proposed legislation or procedure. It is probable that some more acceptable form of federal support for engineering experiment stations may result from the studies now being made by the President's committees and it may be advisable to wait for their recommendations.

The American Engineering Council's natural position in this matter is to represent the

(*Continued on page 476*)

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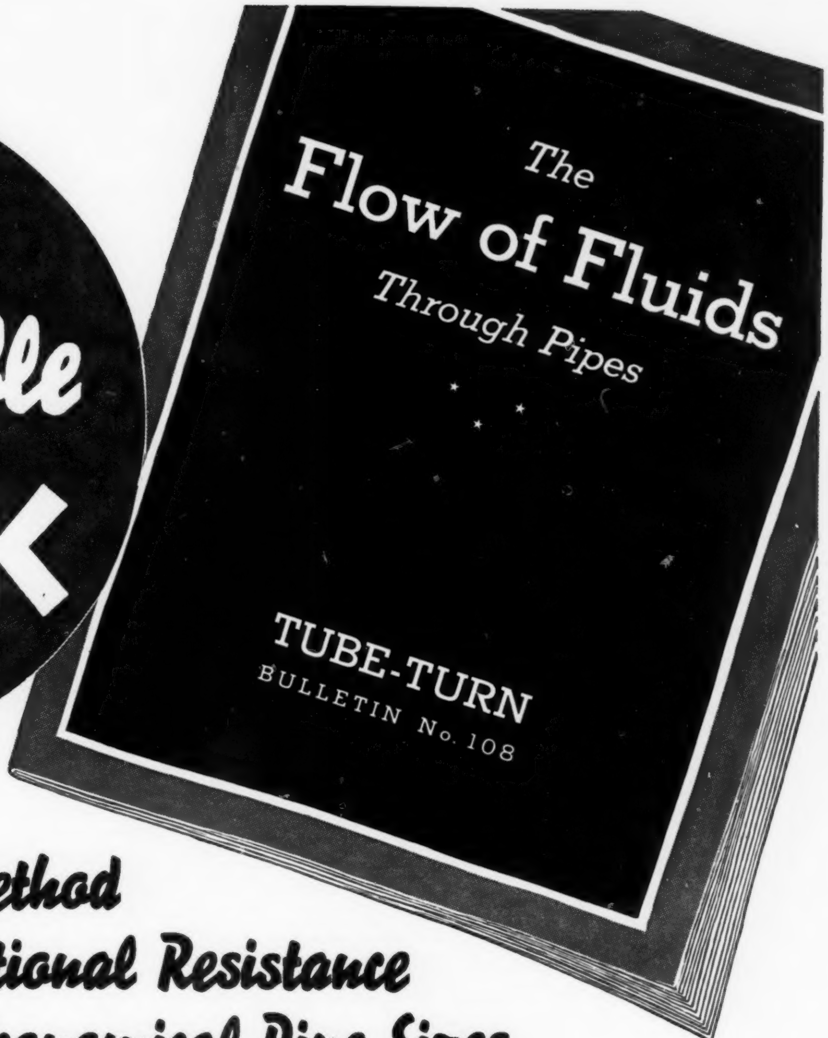

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engineering viewpoint and the engineering profession of the country in the public welfare, and the staff is reluctant to go into controversy beyond that point in support of any legislation. It is, therefore, endeavoring to confine its work, in this connection, to the accumulation and dissemination of information concerning the several pieces of legislation including the opinions of member engineering organizations and its own committees.

The A.E.C. staff is in contact with the chairmen of the President's committees and will announce additional information on this issue as it becomes available.

A.E.C. Follows Patent Legislation

THE American Engineering Council has recently issued the following information on the status of patent legislation in Congress.

Of most importance as regards current patent legislation is S.475 introduced by Senator McAdoo of California on January 8 and referred to Judiciary and Patents Committees on Jan. 19, 1937. It establishes a Court of Patent Appeals consisting of a presiding judge and four associates (at $13,500 and $13,000) who shall have demonstrated special aptitude in patent matters. Such judges shall hold office during good behavior. Three shall constitute a quorum, a majority of those sitting being necessary for a decision. The court shall have exclusive appellate jurisdiction to review decisions of district courts (*a*) in cases arising under the patent laws; (*b*) in equity proceedings to obtain patents; (*c*) in interference proceedings; (*d*) in declaratory judgment proceedings involving patent rights; (*e*) in patent injunction proceedings; (*f*) in patent-infringement suits—except cases originating in Court of Claims or where a direct appeal may be had to the United States Supreme Court. For purposes of procedure, writs, damages, etc., the court is equivalent to a circuit court of appeals. It authorizes appointments of three scientific advisors[1] (at $12,000) to assist the judges in scientific and technological matters.

A companion act was proposed by Congressman Connery of Massachusetts in H.R.5636 on March 15, 1937, and referred to the Judiciary Committee. It establishes a court of patent appeals—similar to S.475.

Another point of view is found in H.R.5855 by Congressman Crosser of Ohio introduced on March 23, 1937, and referred to the Judiciary Committee. It establishes a Court of Patent Appeals, with one chief justice appointed by the President with the consent of the Senate and four associate justices designated by the Chief Justice of the Supreme Court from among the circuit and district judges, for 6-year terms. If a circuit or district judge is appointed chief justice, he shall vacate his office. This court shall have jurisdiction to review decisions of the district courts in patent cases (except those originating in the Court of Claims) with review in the United States Supreme Court on certiorari. Appeals must be taken within six months; in case of interlocutory injunctions, appeals taken within 30 days shall be given precedence, but shall not stay proceedings below in other respects.

According to Senator McAdoo, the Court of Patent Appeals would not replace the present Court of Customs and Patent Appeals which reviews appeals from the Patent Office—U.S.C.28: ch. 8—but would have jurisdiction to review decisions of the district courts in patent cases.

[1] Comments on this bill were offered by the American Engineering Council in a statement in the April, 1937, issue of MECHANICAL ENGINEERING, page 311.

Copyrights and Secrecy

The current copyright situation does not seem to involve the engineer although there are several pieces of such legislation before Congress. S.7 introduced by Senator Duffy of Pennsylvania on Jan. 6, 1937, and referred to the Patents Committee carries miscellaneous amendments to the copyright provisions of the code—U.S.C. title 17, March 4, 1909—so that the law will conform more closely to the international convention for protection of literary and artistic works, and protect more fully literary and artistic efforts disseminated by recent scientific inventions, including motion pictures, radio, telegraphy, television, and other means of transmission.

H.R.5275 introduced by Congressman Daly of Pennsylvania on March 3, 1937 and referred to the Patents Committee proposes an act similar to S.7 including miscellaneous amendment to the copyright laws.

Of somewhat different intention is H.R.6072 introduced by Congressman Whelchel of Georgia on April 1, 1937, and referred to the Patents Committee. It propòses to "Amend and consolidate the acts respecting copyright—U.S.C., title 17, approved March 4, 1909, and provides that all applications for registration shall specify to which of a long list of classes the work in which the copyright is claimed shall go."

Senator Johnson of California (for himself and Senator McAdoo) introduced S.J. Res.87 on Feb. 19, 1937, "to protect the copyrights and patents of foreign exhibitors at the Golden Gate International Exposition." It is the usual type of temporary protection.

H.R.6447 "to protect the right of secrecy in pending applications for patents" was introduced by Congressman Ditter of Pennsylvania on April 15, 1937, and referred to the Patents Committee. It provides that no disclosure relating to any application for a patent which is pending in the Patent Office shall be made to any person except (*a*) the applicant (*b*) persons designated by the courts, and (*c*) in connection with proceedings in court under section 4913, as amended, or section 4915, as amended, of the Revised Statutes.

Positions Available

Engineering Societies Employment Service

SALES ENGINEERS, two, mechanical-engineering graduates with experience in sales and combustion. In lieu of latter, experience in operation or design of oil-refinery plants acceptable. Salary, $250 a month. Apply by letter. Location, New York, N. Y. Y-431.

SALES MANAGER, 30–35, mechanical engineer with experience in power-plant operation and routine office work. To start, work will be direction of general sales correspondence in home office, quotations of blow-off valves, water columns, gages for all power-plant conditions, spray ponds, etc. Later work will be in sales promotion work. Salary, $3000–$4000 a year with opportunity to participate in bonus. Apply by letter. Location, East. Y-1085.

RESEARCH ENGINEER to undertake experimental work and assist in development of new products. Aggressive and capable of proceeding on own initiative in devising tests on gaskets and gasket material, designing equipment for conducting these tests, and recording results. Should also be capable of assembling data for the preparation of manual on subject of gaskets and possibly for personal presentation of such facts before groups of engineers. Salary, $300–$400 a month. Apply by letter. Location, East. Y-1274.

GRADUATE MECHANICAL ENGINEER, 35–40, to act as assistant plant engineer. Must have eight or more years' experience in manufacturing plant, and ability to assume eventually complete charge of plant and electrical maintenance, equipment installation, boilerhouse operation and machine shop. Engineer with practical experience in plant maintenance will be given preference. Must have New York State Professional Engineer's license. Should have pleasing personality and ability to manage people. Salary, $300–$350 a month. Apply by letter. Location, New York State. Y-1340.

WRITER, graduate mechanical engineer, about 30, with experience in operation and maintenance of mechanical equipment including prime movers such as steam, gas, and Diesel engines. Salary, $60 a week. Apply by letter. Location, New York, N. Y. Y-1346.

MECHANICAL ENGINEER to act as assistant to works manager of manufacturing concern. Must be thorough mechanic, with actual experience in shop. Practical and recent design experience also essential. Salary, $300–$350 a month. Apply by letter. Location, Middle West. Y-1348-C.

ENGINEER, 35–50, to take charge of general drafting room. Must have considerable executive ability and sound mechanical judgment, and be able to calculate strains, stresses, loads, and other data necessary to good me-

(*Continued on page 478*)

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chanical design. Will be in charge of about 25 draftsmen. Company manufactures textile machinery. Salary, $5000 a year. Apply by letter. Location, New England. Y-1409.

EXECUTIVE, mechanical engineer. Must be capable of directing eventually entire engineering work of company manufacturing textile machinery. Salary, $5000–$7500 a year. Apply by letter. Location, New England. Y-1410.

MOLD DESIGNER thoroughly experienced in molds for plastic materials. Must be able to handle entire work, from original layout to finished shop drawing. Apply by letter giving age, experience, present connection, salary desired. Location, New Jersey. Y-1415.

SUPERVISOR for stress analysis. Must be capable of stressing complete airplane and acting as chief engineer. Apply by letter. Location, New Jersey. Y-1419.

GRADUATE MECHANICAL ENGINEER, 35–45, American, to act as executive assistant to works manager. Work will involve supervision of and responsibility for company's entire production, and will necessitate knowledge of and experience in both light and heavy machine-tool operations, tool-room work, and general plant maintenance. Must have executive capacity to coordinate wide variety of operations and plan production properly. Salary, $5000–$7000 a year. Apply by letter. Location, New Jersey. Y-1421.

MAINTENANCE AND MECHANICAL SUPERVISOR, 35–50, with broad experience in upkeep of machinery and buildings. Practical machine-shop experience essential. Company manufactures copper wire and cable. Plant covers 15 acres. Salary, $300 a month. Apply by letter. Location, New York State. Y-1467.

ASSOCIATE EDITOR, 28–45, for technical magazine. Must have good engineering education and broad experience in power field, with emphasis on steam power plants. Clear thinker, good writer, versatile engineer with good personality. Editorial experience not essential. Opportunity. Apply by letter giving extensive outline of technical and personal qualifications indicating salary expected. Location, New York, N. Y. Y-1484.

DESIGNER, mechanical engineer, about 40. Must be able to figure stresses in heavy apparatus and know latest developments in welding. Should be thoroughly competent designer. Salary, $4000–$6000 a year. Apply by letter. Location, Massachusetts. Y-1499.

GENERAL MANAGER for factory employing about 80 men, manufacturing ground and lapped parts of highest grade and precision on modern quantity-production basis. Equipment consists of latest type of grinding, lapping, milling, and screw machines. Must be able to take full charge of factory, including purchasing, and to organize various departments to increase production. Only an engineer thoroughly familiar with modern quantity-production methods and all phases of grinding, lapping, and screw-machine work will be considered. Must have held executive positions with reputable concerns. Apply by letter giving full particulars of training, experience, references. Include photograph. Location, Middle West. Y-1507-C.

WORKS MANAGER, mechanical engineer, 35–45, with experience in machine-tool operation, particularly in the jobbing type of shop. Knowledge of foundry practice would be desirable. Should have held position as superintendent or works manager, and be able to handle labor as plant employs approximately 600. Salary, $6000–$7000 a year. Apply by letter. Location, Middle West. Y-1512-C.

SALES MANAGER for company manufacturing motors, generators, control apparatus, etc. Must be resident of Buffalo, Rochester, Syracuse, N. Y. district. Apply by letter. Y-1521.

Candidates for Membership in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after June 25, 1937, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers at once.

NEW APPLICATIONS

BARD, LIEUT. COMDR. NATHAN W., Pearl Harbor, T. H.
BERNA, TELL, Shaker Heights, Cleveland, Ohio
BRAND, FREDERICK F., Pittsfield, Mass.
CASTILLO, CHARLES ALBERT, Jamaica, L. I., N. Y.
COOP, A. B., Boston, Mass.
DODDS, ROBERT H., New London, Conn.
DRAKE, CHARLES E., Stroudsburg, Pa.
ERICKSON, E. A., Casper, Wyo.
FUINA, FRANK J., New York, N. Y.
FUNK, JAMES MORRIS, Ottawa, Ill.
GIBSON, JOHN S., West View, Pa.
HERZFELD, EUGENE, New York, N. Y.
HORSTKOTTE, E. H., Erie, Pa.
JERNSTROM, KARL W., Arlington, N. J.
LANDE, CLARENCE C., Appleton, Wis.
LANDES, BENJAMIN D., Pittsburgh, Pa.
LICHTENBERG, CHESTER, Ft. Wayne, Ind.
LINDE, LEONARD J., Philadelphia, Pa.
LINDENMEYR, ROBERT E., NEW YORK, N. Y.
MAGUIRE, EDWARD L., NEWARK, N. J.
MARTHENS, R. S., Pittsburgh, Pa.
McDONALD, LAWRENCE L., Chicago, Ill.
MORRISON, THOMAS, Fergus, Ontario, Canada
NICHOLSON, CHARLES C., Wilmington, Del.
PANANOS, JAMES D., New York, N. Y.
PETROVSKY, EUGENE I., Brooklyn, N. Y.
POWERS, JAMES H., Ft. Wayne, Ind.
PURVIS, EDWARD D., New York, N. Y.
REYNOLDS, JOHN T., Independence, Mo.
SATTLER, CARL S., Chicago, Ill.
SCHMIDT, RICHARD B., Springfield, Ohio
SEARS, WALTON H., Arlington, Mass.
SMITH, A. JEOFFREY, Badulla, Ceylon
THORNTON, FRANK J., Pittsburgh, Pa.
TUCKER, R. G., JR., Chicago, Ill. (Re)
TUPLING, CHARLES GORDON, Portland, Oregon (Re)
WILLIAMS, CARL L., Matahambre, Cuba
WINNE, HARRY A., Schenectady, N. Y.

CHANGE OF GRADING

Transfer from Member

COLDWELL, E. S., New York, N. Y.

Transfers from Junior

HILLS, L. W., San Francisco, Calif.
KUGLER, ARTHUR N., Ridgewood, N. J.
LYTLE, JOHN E., Jersey City, N. J.
WORTH, DANIEL B., Columbus, Ind.

Necrology

THE following deaths of members have recently been reported to the office of the Society:

ARKEBAUER, JESSE O., April 13, 1937
BOUSFIELD, ALFRED, March 19, 1937
CRAIG, DUDLEY P., March 26, 1937
FERNALD, ROBERT H., April 24, 1937
GAMMETER, HARRY C., April 10, 1937
HEPTINSTALL, W. G., October 1, 1936
HOOD, OZNI P., April 22, 1937
KING, CHAS. G. Y., February 21, 1937
SIBERT, MARTIN LUTHER, March 31, 1937
STILES, ARCHIE M., March 5, 1937
TROST, PAUL A., April 13, 1937

A.S.M.E. Transactions for April, 1937

THE May, 1937, issue of the Transactions of the A.S.M.E., contains the following papers:

The Forced-Draft Spreader Stoker (FSP-59-6), by J. F. Barkley
Incinerators—Municipal, Industrial, and Domestic (FSP-59-7), by H. S. Hersey
Temperature and Combustion Rates in Fuel Beds (FSP-59-8), by M. A. Mayers
The Separation and Emission of Cinders and Fly Ash (FSP-59-9), by A. C. Stern
The Springwells Station of the Detroit Department of Water Supply (HYD-59-3), by W. C. Rudd and B. J. Mullen
Application of Tension-Impact Tests (IS-59-2), by G. F. Jenks
Maintenance of High-Speed Diesel Engines on the Canadian National Railways (RR-59-2), by I. I. Sylvester
Resistance of Lightweight Passenger Trains (RR-59-3), by A. I. Totten
Sanforizing Methods Up to Date (TEX-59-1), by C. H. Ramsey

DISCUSSION

On previously published papers by M. F. Sayre and A. V. deForest; F. G. Straub and T. A. Bradbury; H. W. Fletcher; O. W. Boston, W. W. Gilbert, and C. E. Kraus; G. M. Bean; J. E. Younger; C. A. Wills and F. L. Lindemuth; F. G. Flocke and J. G. Schoener; and L. J. Hooper.